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ERETMOCERUS HALDEMAN (HYMENOPTERA: APHELINIDAE) IN THE UNITED STATES, WITH DESCRIPTIONS OF NEW SPECIES ATTACKING *BEMISIA* (*TABACI* COMPLEX) (HOMOPTERA: ALEYRODIDAE)

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Abstract.—A key to species of *Eretmocerus* that occur in the continental United States is provided. ***Eretmocerus eremicus*, n. sp., *E. joeballi*, n. sp., *E. staufferi*, n. sp.**, and ***E. tejanus*, n. sp.,** all reared from *Bemisia* (*tabaci* complex) collected in the United States, are described. Redescriptions of *Eretmocerus californicus* Howard, *E. corni* Haldeman, *E. haldemani* Howard, and *E. portoricensis* Dozier are provided. *Eretmocerus debachi* Rose and Rosen, *E. furuhashii* Rose and Zolnerowich, and *E. illinoisensis* Dozier are discussed. Lectotypes are designated for *Eretmocerus californicus* Howard, *E. haldemani* Howard, and *E. portoricensis* Dozier.

Key Words: *Eretmocerus*, Aphelinidae, *Bemisia*, Aleyrodidae, biological control

Species of *Eretmocerus* Haldeman, 1850 (Hymenoptera: Chalcidoidea: Aphelinidae) are attracting widespread interest because of population explosions of *Bemisia* (*tabaci* complex) (Homoptera: Aleyrodidae) around the world (Rose et al. 1996). All known species of *Eretmocerus* are primary parasites of whitefly, and species of *Eretmocerus* have been purposefully utilized in effective biological control programs (Rose and DeBach 1991–1992; Rose and Rosen 1991–92; Rose 1988). This paper, which is part of a larger study of *Eretmocerus* species of the world, is designed to clarify characterizations of named species in the U.S., and to describe new species that attack *Bemisia* (*tabaci* complex) in the U.S.

Because of confusion regarding the use of the names *Bemisia tabaci* (Gennadius) A-strain, *B. tabaci* B-strain, and *B. argentifolii* Bellows and Perring on specimen labels and in the literature (Brown et al. 1995), we refer to hosts from this group as *Bemisia* (*tabaci* complex). Species of *Bemisia* (*tabaci* complex) have emerged as a major agricultural pest attacking a variety of food, cash, and ornamental crops in the United States and abroad. *Bemisia* (*tabaci* complex) attacks over 500 plant species in 74 families (Mound and Halsey 1978; Brown and Bird 1992) and new host plants are continually being added (Gill 1992; Costa et al. 1993). Crop damage occurs due to feeding, honeydew production and resultant sooty mold, and disease transmission. Species in the *Bemisia* (*tabaci* complex) transmit more than 15 viruses (Byrne et al. 1990) that cause more than 40 plant diseases (Brown and Bird 1992). Reflecting the current U.S. situation, *Bemisia* (*tabaci* complex) is a major pest of crops in Mexico, the Caribbean, Central and South America, the Middle East, India, and parts of Africa.

Biological control research to attain population regulation of *Bemisia* (*tabaci* complex) in the U.S. is emphasizing evaluation of naturally occurring species of parasitic Hymenoptera and importation of exotic populations and species of parasites. The majority of native and imported species are found in *Eretmocerus* and *Encarsia* Foerster (Hymenoptera: Chalcidoidea: Aphelinidae). Polaszek et al. (1992) provided a key and discussion of *Encarsia* species that attack *Bemisia* (*tabaci* complex). Schauff et al. (1996) furnished a pictorial key and discussion of species of *Encarsia* that attack whitefly in North America. Species of *Amitus* Haldeman (Hymenoptera: Platygastridae) also have been reared from *Bemisia* (*tabaci* complex) (Viggiani and Evans 1992).

Surveys to obtain samples of *Bemisia* (*tabaci* complex) and its parasites from various host plants in the U.S. have been undertaken primarily in Arizona, California, Florida, and Texas. These states have suffered the greatest damage to field crops and subsequent losses to *Bemisia* (*tabaci* complex), so biological control research efforts have been emphasized in these areas. It is vitally important that researchers in these and other areas are able to identify the biological entities they are discovering, importing, colonizing and evaluating.

There are currently 8 described species of *Eretmocerus* from the New World, and 30 species are known from the Old World. Given that there are nearly 1200 described species of whitefly, and that species of *Eretmocerus* are known from all continents where whitefly occur, there are undoubtedly many more undescribed species of *Eretmocerus*. Because most species of *Eretmocerus* have been reared from agricultural pests, little is known of the actual range of these species. Likewise, little is known about species found outside of agricultural settings.

The literature encompassing the taxonomy of *Eretmocerus* is disparate in its comprehensiveness, and researchers have relied on historical taxonomy to provide names for numerous species of *Eretmocerus* that are currently being studied and transferred nationally and internationally. These historical names often find their way into new literature and are then generally adopted, which may obscure the actual species being studied. For example, two of the species described in this paper were called *E. californicus* or *E.* sp. nr. *californicus* for many years.

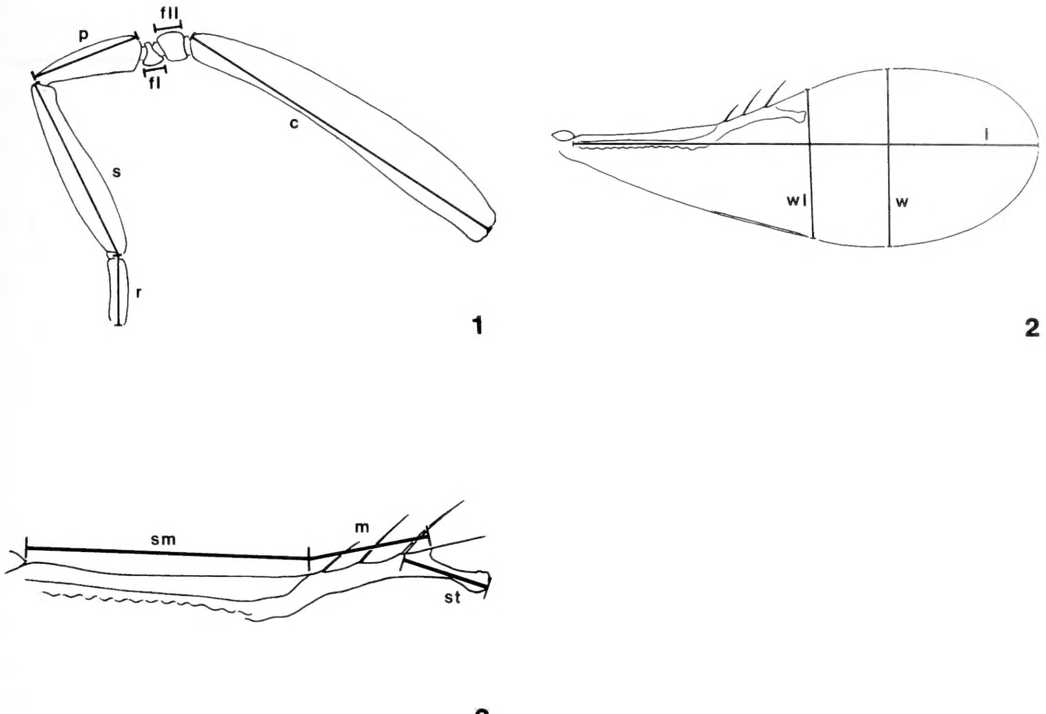
Previous studies (Rose and Rosen 1991–1992, Rose and Zolnerowich 1994, Rose et al. 1996, Hunter et al. 1996) have emphasized developing criteria for the characterization of species based on morphology, pigment patterns of males, reciprocal mating trials, and electrophoretic analysis. These studies all indicate that minor morphological differences in the size, shape, or chaetotaxy of the habitus, antennae, and forewings, and pigment patterns of males, are significant species characters.

Males of different species of *Eretmocerus* are very similar unless they have features such as distinct pigment patterns. The poor condition of male specimens available for *Eretmocerus haldemani* and *E. illinoisensis* preclude their separation in the key to species. Males are unknown for *Eretmocerus joeballi* and *E. portoricensis*.

METHODS

High quality microslide mounts are necessary to correctly examine and identify species of *Eretmocerus*. Because clearing and mounting specimens in balsam removes all or most of their color, most specimens used in this study were mounted in Hoyer's medium as described by Rosen and DeBach (1979), and the cover slips were sealed with two coats of red GLPT, a nonconducting insulating varnish used in electronics (GC Electronics, Rockford, Illinois). Other specimens were critical point-dried and mounted on cards prior to mounting in balsam. Most primary type material was mounted in balsam.

Position of the body and antenna on microslides is critical for proper identification. The antenna should be examined from the lateral aspect. Viewing the antenna from any other angle obscures the true length and shape of the segments. In many instances, the antennae were removed from the head



Figs. 1–3. 1, ♀ antenna. 2, Forewing. 3, Venation of forewing. c = length of club, fI = length of first funicular segment, fII = length of second funicular segment, 1 = length of forewing, m = length of marginal vein, p = length of pedicel, r = length of radicle, s = length of scape, sm = length of submarginal vein, st = length of length of stigmal vein, w = greatest width of disc, wI = width I.

and mounted separately on the same slide. Wings should be positioned away from the body to reveal their shape and allow accurate measurements to be made.

Length of the body was measured from critical point-dried specimens using an eyepiece micrometer when possible. Other measurements of specimens mounted in balsam or Hoyer's were taken using an eyepiece micrometer or a digitizing tablet. The maximum length of each antennal article in lateral view was measured (Fig. 1). The antennal ratios given in descriptions are the ratios of the lengths of the radicle : scape : pedicel : club. Unless expressed as a range, the length : width ratios represent average values.

Length and width of the forewing were measured as shown in Fig. 2. The maximum length (1) and width of the wing across the disc (w) were measured. Width I (wI) is the distance between the distal end of the frenal fold and the anterior margin of the forewing above the distal end of the stigmal vein. Points of measurement for the lengths of the submarginal, marginal, and stigmal veins are shown in Fig. 3. The ratios of the lengths of the longest anterior and posterior alary fringes (Fig. 5) to the width of the wing are given, as is the number of tubercles (Fig. 11), which are present on the ventral side of the wing.

In many instances, the distal boundary of the marginal vein and the advent of the stigmal vein were not clearly delimited. In those cases, the end of the marginal vein and the beginning of the stigmal vein were taken at the base of the distal large seta on the marginal vein (Fig. 3, st).

Descriptions of color for critical point-dried and specimens mounted in Hoyer's may differ because of differences in speci-

Table 1. Species of *Eretmocerus* in the U.S. and original collection data.

Species	Author	Year	Original Host Insect
corni types lost	Haldeman	1850	*Tetraleurodes corni* (Haldeman) [= *Aleurodes corni* Haldeman]
corni neotype	Dozier	1932	*Trialeurodes packardi* (Morrill) [= *Trialeurodes morrilli* (Britton)]
californicus	Howard	1895	unknown ''Aleyrodes''
haldemani	Howard	1908	*Aleuroplatus coronata* (Quaintance) [= *Aleyrodes coronata* Quaintance]
illinoisensis	Dozier	1932	unknown
portoricensis	Dozier	1932	*Aleurothrixus floccosus* (Maskell)
debachi	Rose & Rosen	1991–92	*Parabemisia myricae* (Kuwana)
furuhashii	Rose & Zolnerowich	1994	*Parabemisia myricae* (Kuwana)
eremicus	Rose & Zolnerowich	1997	*Bemisia* (*tabaci* complex), possibly *Trialeurodes*
joeballi	Rose & Zolnerowich	1997	*Bemisia* (*tabaci* complex)
staufferi	Rose & Zolnerowich	1997	*Bemisia* (*tabaci* complex), *Trialeurodes abutiloneus* (Haldeman)
tejanus	Rose & Zolnerowich	1997	*Bemisia* (*tabaci* complex)

[1] Host plant probably *Quercus* (R. Gill, personal communication).

men preparation. Specimens mounted in Hoyer's do not show colors as well as critical point-dried material, but do show fuscous pigment patterns well. Descriptions of color or pigment are given for both critical point-dried and Hoyer's-mounted specimens where appropriate.

For new and described species, label data for primary types is presented exactly as recorded on the specimen labels, with the data for each individual label enclosed by quotation marks and each line of the label separated by a slash. Label data for material other than primary types are standardized and multiple records from the same locality may be combined. Table 1 provides summary information such as original locality, host, and host plant for the species of *Eretmocerus* discussed here.

The following acronyms represent institutions or individuals who loaned material for study, are repositories for type material, or are otherwise mentioned in the text: BMNH, The Natural History Museum, London, United Kingdom; CDFA, California Department of Food and Agriculture, Sacramento; HU, The Hebrew University, Rehovat, Israel; INHS, Illinois Natural History Survey, Champaign; MJR, personal collection of M. J. Rose; NSM, National Science Museum, Tokyo, Japan; TAMU, Texas A&M University, College Station; UCR, University of California, Riverside; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

KEY TO SPECIES OF *ERETMOCERUS* IN THE UNITED STATES

1 Female, antenna with 2 funicular segments (e.g., Figs. 1, 8) 2
– Male, antenna without funicular segments 11
2(1) Mesosoma brown to brown orange, contrasting strongly with head and metasoma (Fig. 25) . . . . *E. staufferi*, n. sp.
– Body yellow, mesosoma not contrasting with head and metasoma 3
3(2) Mesoscutum with 4 setae (Fig. 15) 4

Table 1. Continued.

Original Host Plant	Original Locality, Date
Cornaceae: *Cornus sericea,* dogwood	Pennsylvania, 1847
Balsaminaceae: *Impatiens biflora,* jewel weed	Pennsylvania, White Clay Creek, 1929
Fagaceae: *Quercus agrifolia,* California live oak	California, Los Angeles, 1887
unknown[1]	California, Berkeley, 1908
unknown	Illinois, Elizabethtown, 1932
Burseraceae: *Bursera simaruba* Zygophyllaceae: *Guaiacum officinale*	Puerto Rico: Bayamon & Central Aguirre, 1925
Rutaceae: *Citrus* spp.	California, Orange County, 1982
Moraceae: *Morus* sp., mulberry	Japan: Honshu, 1979
Malvaceae: *Gossypium hirsutum,* cotton	Arizona, Phoenix, 1991
Moraceae: *Morus* sp. Solanaceae: *Solanum*	California, Bakersfield, 1993
Solanaceae: *Lycopersicon,* tomato	Texas, College Station, 1993
Cruciferae: *Brassica oleracea,* cabbage	Texas, Mission, 1994

– Mesoscutum with 6 setae 5

4(3) Parapsis with 2 setae; club 4.1–4.5 times as long as its greatest width (Fig. 8) . . . . *E. debachi*

– Parapsis with 3 setae (Fig. 15); club 4.3–5.6 times as long as its greatest width (Fig. 13) . . . . *E. furuhashii*

5(3) Club 3.2–3.8 times as long as wide, with dorsal surface convex and contrasting with straight ventral surface (Fig. 20) . . . . *E. portoricensis*

– Club 4.5–8.3 times as long as wide, and with dorsal and ventral surfaces more or less parallel (e.g., Figs. 4, 26) 6

6(5) Dorsal surface of club apically tapered so that apex forms a broad point (Fig. 4); radicle 0.6 times or more as long as scape . . . . *E. californicus*

– Apex of club truncate; radicle 0.35–0.50 times as long as scape (e.g., Figs. 16, 26) 7

7(6) Pedicel short, 2–2.3 times as long as wide; club 4.5–5.1 times as long as wide (Fig. 18); ovipositor 1.5 times as long as club and 1.3 times as long as midtibia . . . . *E. joeballi*, n. sp.

– Pedicel longer, 2.5–4 times as long as wide; club 5.9–8.3 times as long as wide (e.g., Figs. 6, 16); ovipositor shorter than or equal to length of club or midtibia . . . 8

8(7) Scape at least 6.5 times as long as wide (Fig. 16); midbasitarsus 8.5 times as long as wide . . . . *E. haldemani*

– Scape 3.5–5.5 times as long as wide (e.g., Fig. 10); midbasitarsus 5.5–8.3 times as long as wide 9

9(8) Pedicel 2.4–3.1 times as long as wide, and 0.25–0.3 times as long as club (Fig. 6); reared from *Trialeurodes* . . . . *E. corni*

– Pedicel 3–4 times as long as wide, and 0.29–0.39 times as long as club (Fig. 10); reared from *Bemisia* (*tabaci* complex) and possibly *Trialeurodes* 10

10(9) Gastral tergite II usually with 1 pair, but occasionally 2 pairs, of lateral setae (Fig. 12); gastral sternites anterior to base of ovipositor usually with a group of 4–5 setae, occasionally with 3–6 setae . . . . *E. eremicus*, n. sp.

– Gastral tergite II usually with 2 pairs, but occasionally 1 pair, of lateral setae (Fig. 28); gastral sternites anterior to base of ovipositor usually with a group of 7–8 setae, occasionally with 5–6 setae . . . . *E. tejanus*, n. sp.

11(1) Mesoscutum with 4 setae (Fig. 15) 12

– Mesoscutum with 6 setae 13

12(11) Parapsis with 2 setae; mesoscutum with dark fuscous "T" shape; scutellum completely fuscous (Fig. 29) . . . . *E. debachi*

– Parapsis with 3 setae (Fig. 15); mesoscutum with light fuscous "T" shape; scutellum medially fuscous, lateral areas unpigmented (Fig. 31) . . . . *E. furuhashii*

13(11) Entire mesosoma brown to brown orange, contrasting strongly with head and metasoma (Fig. 32) . . . . *E. staufferi*, n. sp.

– Mesosoma not brown to brown orange, although fuscous pigment patterns on pronotum, mesoscutum, or scutellum may be present or absent (e.g., Figs. 30, 33) . . . 14

14(13) Mesoscutum with longitudinal fuscous bands (Fig. 33) . . . . *E. tejanus*, n. sp.

– Mesoscutum without longitudinal fuscous bands 15

15(14) Mesoscutum fuscous along anterior margin (Fig. 30), or with a light fuscous "T" shape (as in Fig. 31), or evenly fuscous 16

– Mesoscutum not fuscous 17

16(15) Hind tibia fuscous . . . . . . *E. eremicus*, n. sp.

– Hind tibia not fuscous . . . . *E. corni*

17(15) Scape 2.5–2.8 times as long as pedicel . . . . *E. californicus*

– Scape 3.2–4 times as long as pedicel . . . . *E. haldemani*, *E. illinoisensis*

Eretmocerus californicus Howard (Figs. 4–5)

Eretmocerus californicus Howard, 1895: 16 [USNM, examined].

Type material. Lectotype here designated, ♀ mounted in balsam on a slide labelled, "Name Eretmocerus/californicus/Howard/REMOUNT/Det HOWARD 19 1895/Coll D. W. Coquillett/No. USNM 2699/Corr. LECTOTYPE" "♀/1" "Loc Los Angeles/California/Date VI-9 19 1887/Host Aleyrodes/Det 19/On Quercus/agrifolia".

There are an additional five ♀ and 16 ♂ paralectotypes mounted on 15 slides [USNM].

Diagnosis. Females of *E. californicus* can be distinguished by the length of the radicle, which is 0.6× or more than the length of the scape, the extremely reduced first funicular segment, and the tapered shape of the club (Fig. 4). *Eretmocerus californicus* is most similar to *E. eremicus* and *E. tejanus*, which differ in having the radicle only 0.4–0.5× the length of the scape, the first funicular segment is not as reduced, and the club is not tapered (Figs. 10, 26).

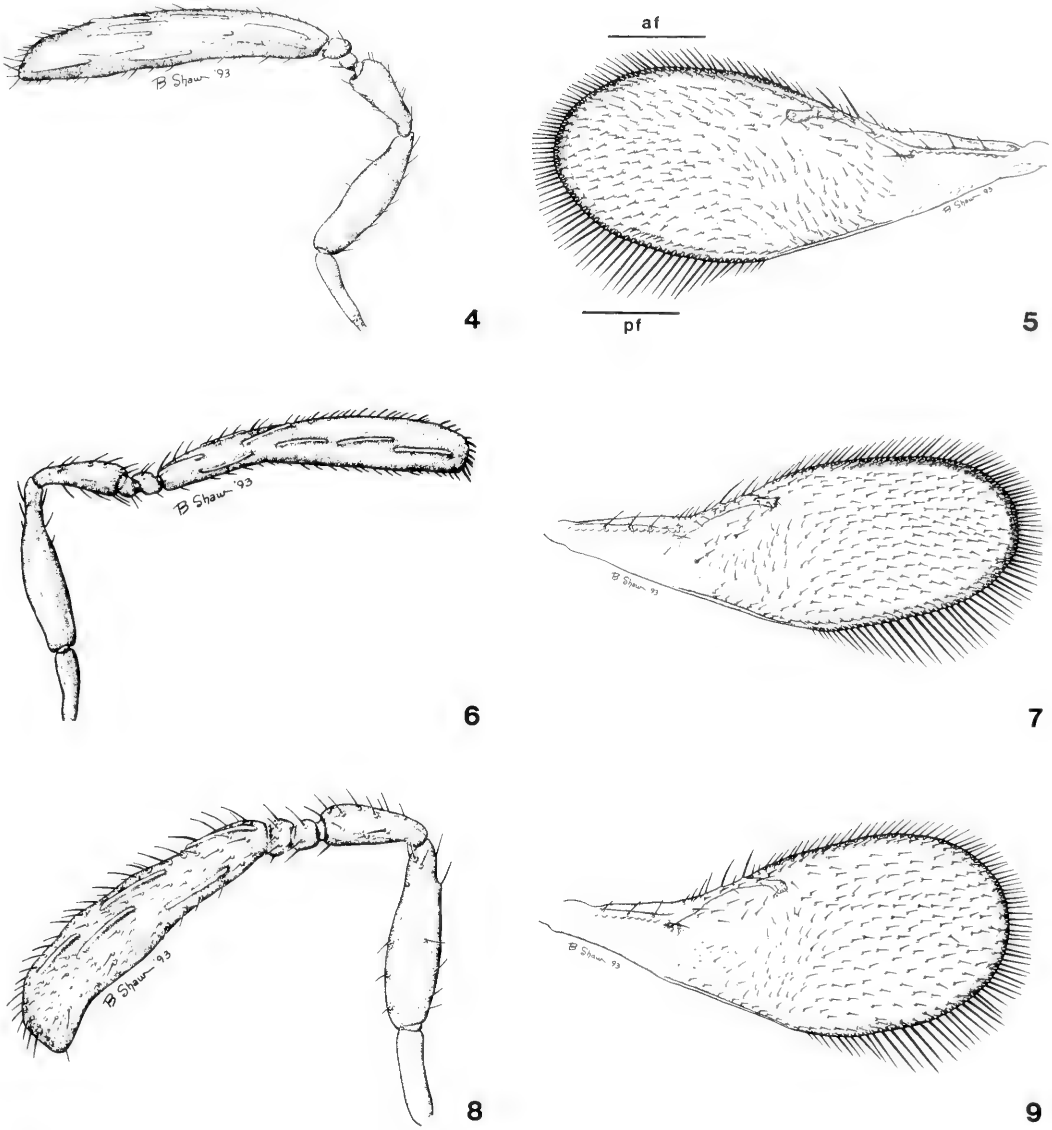
Males of *E. californicus* lack pigment patterns on the mesoscutum, and the scape is 2.5–2.8 × as long as the pedicel. *Eretmocerus eremicus* and *E. tejanus* differ by having distinct fuscous pigment patterns on the mesoscutum (Figs. 30, 33).

Female.—Length and body color could not be accurately determined from available slide-mounted specimens. Wings hyaline.

Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate. Antenna (Fig. 4) with radicle 5.4× as long as wide; scape 3.9× as long as wide, 1.5–1.6× length of radicle, 1.6× length of pedicel, 0.5× length of club; pedicel 2.6× as long as wide, slightly shorter than radicle, 0.6× length of scape, 0.3× length of club. Funicle I triangular, 1.2× as wide as long and much smaller than funicle II; funicle II 1.8× as wide as long. Club with apex apically tapered, 5.2–6.6× as long as wide, 2× length of scape, 3.2× length of pedicel. Antennal ratio 1:1.5:1.0:3.1.

Mesoscutum trapezoidal with 6 setae and with reticulate sculpture in the anterior ⅓, remainder with elongate reticulate sculpture laterally and substrigulate sculpture medially. Parapsis with 2 setae and faint reticulate to substrigulate sculpture; axilla with 1 seta and sculpture similar to parapsis. Scutellum with 4 setae and 2 placoid sensilla lateral to and close to posterior setae, laterally with elongate reticulate sculpture, remainder with elongate to substrigulate sculpture. Propodeum smooth. Endophragma extending to posterior half of gastral tergite II.

Forewing (Fig. 5) 2.7× as long as wide at width I, 2.4× as long as maximum width of disc. Longest anterior alary fringe 0.2× width of disc, longest posterior alary fringe 0.4× width of disc. Single seta at base of wing present or absent; distal portion of costal cell with 2–5 setae. Marginal vein with 3 long setae, 10–12 setae usually between marginal vein and linea calva. Linea



Figs. 4–9. 4–5, *Eretmocerus californicus*. 4, ♀ antenna. 5, ♀ forewing. 6–7, *E. corni*. 6, ♀ antenna. 7, ♀ forewing. 8–9, *E. debachi*. 8, ♀ antenna. 9, ♀ forewing. af = anterior alary fringe, pf = posterior alary fringe.

calva closed posteriorly by setae, with 12–15 tubercles on ventral surface of wing near posterior end of linea calva; a group of 31–43 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 171–175 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 2.8:1.1:1.

Hind wing 6.9× as long as wide, with 7–9 setae in center.

Gastral tergite I covered with strong reticulate sculpture; lateral margins of gastral tergites imbricate with dense stippling; gastral tergites I–VI with paired setae as follows: 1, 1, 2, 2–3, 2, 1. Syntergum with 4 setae.

Ovipositor slightly exserted and equal to length of club, 3× length of pedicel, 1.9× length of scape, and 1.1× length of midtibia.

Male.—Body color could not be accurately determined from available slide-mounted specimens. Mid- and hind tarsi I–III fuscous. Marginal and stigmal veins fuscous, base of forewing and costal cell slightly fuscous.

Host.—Reared from an unknown species of *Aleyrodes*.

Discussion.—Howard's original description and figures of *E. californicus* were based on a series of female and male specimens reared from an undetermined *Aleyrodes* collected by D. W. Coquillett in Los Angeles, California, in 1887. Although Howard (1895) deposited type material in the USNM, and Dozier examined the material in 1932, Compere (1936) was unable to examine *E. californicus* and placed it in his key based on the original description. The type material was lost from about 1932 until 1992.

In 1992, G. Evans found the missing slides of *E. californicus* at the USNM. The specimens on one slide (five female, eight male) were crumpled in dark orange balsam and not suitable for study. All the specimens on this slide have been individually remounted in balsam. G. Evans also remounted broken specimens, including one female, from two other slides labelled as USNM Type No. 2699. The label data for these two new slides, which list "Asterodiaspidis" as the host, do not agree with the label data from the other type slides. We consider this to be an error.

Our figures and redescription are derived from the six remounted females and eight remounted males, and seven male specimens from a single original Howard slide. There are now a total of 16 slides bearing *E. californicus* specimens labelled with the original collection data and identified as USNM Type No. 2699.

It is interesting to note that *E. californicus* was reared from an unknown species of *Aleyrodes* on oak. *Aleuroplatus*, *Tetraleurodes*, and *Trialeurodes* all occur on *Quercus* in southern California. M. Rose and J. B. Woolley (TAMU) were unable to obtain *Eretmocerus* from numerous collections of whitefly, particularly *Tetraleurodes stanfordi* (Bemis), from oaks in Los Angeles County over the past 15 years.

Lack of accurate characterization of *E. californicus* has resulted in misapplication of this name, particularly to species of *Eretmocerus* reared from *Bemisia* (*tabaci* complex) in the U.S. We have not examined any specimens of *E. californicus* reared from *Bemisia* (*tabaci* complex).

Eretmocerus corni Haldeman
(Figs. 6–7)

Eretmocerus corni Haldeman, 1850: 110 [USNM, examined].

Type Material.—Neotype ♀ mounted in balsam on a slide labelled. "Eretmocerus corni Hald./Reared from white-/fly, Asterochiton/sp. on Impatients/biflora./White Clay Creek/Pa. Sept. 16, 1929/H.L Dozier" "Eretmocerus/corni Hald./Designated as/this long-lost/species./♀ + ♂ Neotype/U.S.N.M."

Diagnosis.—Females of *Eretmocerus corni* can be distinguished by the combination of the elongate club that is 5.9–7× as long as wide and the relatively short pedicel, which is only 2.4–3.1× as long as wide, and 0.25–0.29×, rarely 0.30×, as long as the club (Fig. 6). *Eretmocerus corni* is similar to *E. eremicus* and *E. tejanus*, which differ in having the pedicel 3–4× as long as wide and 0.28–0.39× as long as the club (Figs. 10, 26). *Eretmocerus haldemani* also has an elongate club, but it is 7.5-8.3× as long as wide (Fig. 16).

Males of *Eretmocerus corni* have the mesoscutum and scutellum fuscous, and the hind tibia is not fuscous. They are most similar to males of *E. eremicus* and *E. tejanus*. Males of *E. eremicus* differ in having the hind tibia fuscous, and males of *E. tejanus* can be distinguished by the longitudinal fuscous bands on the mesoscutum (Fig. 33).

Female.—Length of specimens in Hoyer's 0.47–0.55 mm. Specimens in Hoyer's with body and antennae pale yellow. Head amber; eyes amber with inner red pigment, ocelli pale. Wings hyaline.

Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate. Antenna (Fig. 6) with radicle 4× as long as wide; scape 4.9× as long as wide and 2.1× length of radicle, 2.2× length of pedicel, 0.4× length of club; pedicel 2.4–3.1× as long as wide, 0.4× length of scape, 0.25–0.29×, and rarely 0.30×, length of club. Funicle I triangular, 1.25× as wide as long; funicle II subquadrate. Club with apex truncate, 5.9–7× as long as wide, 2.5× length of scape, 4.9× length of pedicel. Antennal ratio 1:2.1:1.6:4.7.

Mesoscutum trapezoidal with 6 setae and reticulate sculpture anteriorly, remainder with elongate reticulate sculpture. Parapsis with 2 setae and reticulate to substrigulate sculpture; axilla with 1 seta and reticulate to substrigulate sculpture. Scutellum with 4 setae and 2 placoid sensilla lateral to and slightly closer to posterior setae than to anterior setae, with fine substrigulate sculpture medially, remainder with reticulate sculpture. Propodeum medially reticulate, faintly reticulate on lateral margins. Endophragma extending nearly to posterior margin of gastral tergite IV.

Forewing (Fig. 7) 2.9× as long as wide at width I, 2.7× as long as maximum width of disc. Longest anterior alary fringe 0.16× width of disc; longest posterior alary fringe 0.3× width of disc. Single seta at base of wing present or absent; distal portion of costal cell usually with 3, occasionally 2–5, setae. Marginal vein with 3 long setae; 10–11 setae, occasionally 10–15, between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 12–16 tubercles on ventral surface of wing near posterior end of linea calva; a group of 32–45 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 183–238 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 3:1.3:1.

Hind wing 7.5× as long as wide, with 7–15 setae in center.

Gastral tergite I with faint transverse substrigulate sculpture medially and reticulate sculpture on anterior half of lateral margins; lateral margins of tergites II–VI imbricate with stippling; tergites I-VI usually with paired setae as follows: 1, 1, 2, 2, 2, 1, but occasionally 1, 1–3, 2–3, 2–3, 2, 1. Syntergum with 4 setae.

Ovipositor slightly exserted, 0.8× length of club, 3.4× length of pedicel, 1.8× length of scape, equal in length to midtibia.

Male.—Specimens mounted in balsam with head orange. Apex of scape, pedicel, and multiporous plate sensilla fuscous. Pronotum fuscous. Mesoscutum fuscous, darkest along anterior margin and becoming paler posteriorly; tegula slightly fuscous. Scutellum fuscous, darkest along anterior and posterior margins. Metanotum and propodeum slightly fuscous. Aedeagus slightly fuscous. Fore- and hind tarsi slightly fuscous; distal portion of midtibia and midtarsi I–III fuscous, midtarsus IV less fuscous. Submarginal vein, costal cell, and edges of marginal and stigmal veins fuscous; base of forewing and venation of hind wing slightly fuscous.

Host.—Reared from *Trialeurodes packardi* (Morrill), the strawberry whitefly.

Discussion.—Haldeman's (1850) original description and figure of the type species, *E. corni*, were based on "Two mutilated specimens" reared from *Tetraleurodes corni* (Haldeman) [= *Aleurodes corni* Haldeman]. Unfortunately, Haldeman did not designate a depository for his specimens. Dozier (1932), who was unable to locate the original material, provided a redescription of the species and designated a neotype female based on a series of specimens (15 ♀, 3 ♂) reared from *Trialeurodes packardi* (Morrill) [as *T. morrilli* (Britton)] and an additional field-collected female.

The slide labelled as the neotype lists

"*Asterochiton*" as the host, but Dozier only mentions *Trialeurodes morrilli* as a host in the redescription. Mound and Halsey (1978) do not list any species of *Asterochiton* in the U.S. Dozier's original identification of the host is probably an error. Although Dozier stated the slide bearing the neotype female also contained one additional female and one male specimen, the slide with the red USNM type label only has a single female and single male. Despite these discrepancies, we accept this slide with the red USNM type label as the one with the neotype.

Eretmocerus corni did not successfully reproduce on *Bemisia* (*tabaci* complex) in limited trials at TAMU. It may prove to be important in the biological control of species of *Trialeurodes*.

Other material examined.—**USA**: **Maryland**: Blackwater Refuge, reared from *T. packardi* on wild strawberry, 19.x, 24, 26.x.1942, H. L. Dozier (1 ♀, 2 ♂, USNM); Cambridge, 24, 26, 30.viii., 9.ix.1943, Ex. *Trialeurodes* on *Euphorbia hirsuta*, H. L. Dozier (1 ♀, 6 ♂, USNM); Church Creek, Ex. *Trialeurodes* on Lizard's Tail, 2, 4.x.1942 (1 ♀, 1 ♂, USNM); Church Creek, Ex. Lizard's Tail, 10.x.1942 (1 ♀, USNM); **New York**: Ithaca, Cornell Plantations, 29.ix.1992, *Trialeurodes packardi* on *Impatients pallida*, T92047, G. W. Ferrentino (8 ♀, 4 ♂, MJR); Ithaca, S. of Beebe Lake, 10.viii.1988, ex. *Trialeurodes packardi*, M. Hunter (1 ♂, MJR).

Eretmocerus debachi Rose and Rosen
(Figs. 8–9, 29)

Eretmocerus debachi Rose and Rosen, 1991–1992: 200 [USNM, examined].

Type material.—Holotype ♀ mounted in balsam on a slide labelled, "Name Eretmocerus ♀/debachi/Holotype sp.nov./Balsam/Det Rose 1982/Coll M. Rose/No. B2.76/Corr. USNM/Rose&Rosen 91–92" "Loc Rancho Mission/Viejo, Orange Co., Cal./Date VII.15 1982/Host Parabemisia/myricae/Det Rose 1982/On Valencia orange/and lemons".

There are five ♀ and one ♂ paratypes with the same label data as the holotype. These are deposited with the BMNH, HU, MJR, TAMU, and USNM.

Diagnosis.—Females of *E. debachi* can be distinguished by the deflexed apex of the club (Fig. 8), mesoscutum with 4 setae, and each parapsis with 2 setae. It is most similar to *E. furuhashii*, which differs in having a longer club (Fig. 13) and 3 setae on each parapsis (Fig. 15). *Eretmocerus joeballi* can have the apex of the club slightly deflexed (Fig. 18) but differs in having 6 setae on the mesoscutum.

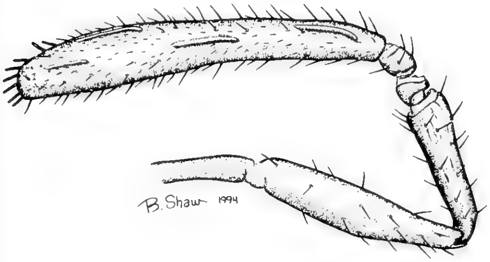
Males of *E. debachi* have each parapsis with 2 setae, a fuscous "T" shape on the mesoscutum, and the scutellum is completely fuscous (Fig. 29). Males of *E. furuhashii* differ in having each parapsis with 3 setae, a very light fuscous "T" shape on the mesoscutum, and the lateral areas of the scutellum are unpigmented (Fig. 31).

Host.—Reared from *Parabemisia myricae* (Kuwana), the bayberry whitefly.

Discussion.—The description of *E. debachi* was based on series of specimens reared from *Parabemisia myricae* collected on citrus in southern California. The taxonomy, biology and history of *E. debachi* in California is well documented (Rose and DeBach 1991–1992, Rose and Rosen 1991–92, Rose and Zolnerowich 1994). This species has been introduced and established in Israel and Turkey, where it is responsible for control of *P. myricae*. Introductions are planned for Spain and France (J. C. Onillon, personal communication) and Morocco (D. Rosen, personal communication).

***Eretmocerus eremicus* Rose and Zolnerowich, new species**
(Figs. 10–12, 30)

Diagnosis.—Females of *E. eremicus* can be distinguished by the club that is 6.5–7.3× as long as wide (Fig. 10), pedicel that is 3–4× as long as wide and 0.3–0.39× as



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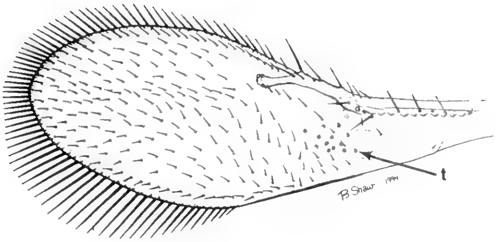

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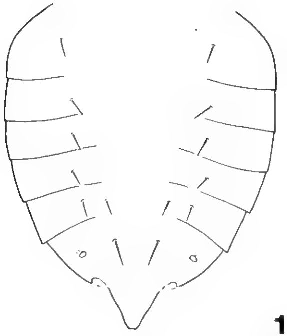

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Figs. 10–12. *Eretmocerus eremicus*. 10, ♀ antenna. 11, ♀ forewing. 12, ♀ gaster. t = tubercle.

long as the club, mesoscutum with 6 setae, and gastral tergite II usually with 1 pair, but occasionally 2 pairs, of lateral setae (Fig. 12).

Females of *E. eremicus* are very similar to *E. corni* and *E. tejanus*. Females of *E. corni* have the pedicel 2.4–3.1× as long as wide and 0.25–0.30× as long as the club, and have not been reliably recorded from *Bemisia* (*tabaci* complex). *Eretmocerus tejanus* has the anterior alary fringe of the forewing slightly shorter (Fig. 27), and gastral tergite II usually has 2 pairs, but occasionally 1 pair, of lateral setae (Fig. 28).

Males of *E. eremicus* have the mesoscutum fuscous along the anterior margin (Fig. 30), or with a light fuscous "T" shape (as in Fig. 31), or evenly fuscous, and the hind tibia is fuscous. Males of *E. corni* do not have the hind tibia fuscous, and males of *E. tejanus* can be distinguished by the longitudinal fuscous bands on the mesocutum (Fig. 33).

Female.—Length of critical point-dried specimens 0.45–0.55 mm. Body light yellow. Head light yellow or yellow white and paler than body; eyes grey green, ocelli red. Scape same color as face, pedicel and flagellum slightly darker. Legs pale yellow and paler than body, tarsal claws dark. Wings hyaline.

Specimens mounted in Hoyer's with body and legs pale yellow amber, legs occasionally slightly darker than body. Head pale to light amber. Antenna pale amber. Wing venation and frenal fold of forewing amber.

Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate. Antenna (Fig. 10) with radicle 4.2× as long as wide; scape 5.1× as long as wide, 2.1× length of radicle, 1.6×

length of pedicel, 0.6× length of club; pedicel 3–4× as long as wide, 1.3× length of radicle, 0.6× length of scape, 0.3–0.39× length of club. Funicle I triangular, 1.1× as wide as long; funicle II 1.1× as long as wide. Club 6.5–7.3× as long as wide, 1.7× length of scape, 2.6× length of pedicel. Antennal ratio 1:2.1:1.3:3.5.

Mesoscutum trapezoidal and with 6 setae, occasionally with supernumary setae, anterior ⅓–½ with reticulate sculpture, medially with substrigulate sculpture, remainder with elongate reticulate sculpture. Parapsis with 2 setae and substrigulate sculpture; axilla with 1 seta and substrigulate sculpture. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae or equidistant, with substrigulate sculpture in median area, remainder with elongate reticulate sculpture. Propodeum with substrigulate sculpture. Endophragma extending to posterior half of gastral tergite IV.

Forewing (Fig. 11) 2.9× as long as wide at width I, 2.7× as long as maximum width of disc. Longest anterior alary fringe 0.17× width of disc, longest posterior alary fringe 0.35× width of disc. Base of wing usually with 1, occasionally 0–2, setae, distal portion of costal cell usually with 2–3 setae. Marginal vein with 3 long setae, 6–12 setae between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 11–14 tubercles on ventral surface of wing near posterior end of linea calva; a group of 24–35 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 120–202 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 3.5: 1.5:1.

Hind wing 6.9× as long as wide and with 5–11 setae in center.

Gastral tergite I with strong substrigulate sculpture anterolaterally, remainder substrigulate; lateral margins of tergites faintly imbricate with stippling; gastral tergites I–IV (Fig. 12) usually with paired setae as follows: 1, 1, 1, 1, 2, 1, but can be 1, 1–2, 1–2, 1–2, 2, 1. Syntergum with 4 setae.

Ovipositor slightly exserted, equal in length to club, 2.6× length of pedicel, 1.7× length of scape, equal in length to midtibia.

Male.—Length of critical point-dried specimens 0.43–0.51 mm. Face light yellow, vertex orange yellow, eyes grey green, ocelli red. Scape same color as face or slightly darker, pedicel and flagellum testaceous. Pronotum dorsolaterally brown. Mesoscutum orange yellow to orange brown and fuscous along anterior margin (Fig. 30), or with a light fuscous "T" shape (as in Fig. 31), or evenly fuscous; parapsis lighter. Scutellum colored as mesoscutum. Dorsellum brown. Propodeum light brown dorsally. Gaster yellow brown to orange brown dorsally, remainder yellow. Coxae pale whitish, proximal ⅓–½ of all femora pale white, remainder tan to light brown, all tibiae light brown, all tarsi brown.

Specimens mounted in Hoyer's with head dark amber. Radicle and scape fuscous; pedicel darker, club slightly fuscous and darker at the base, multiporous plate sensilla dark fuscous. Pronotum fuscous. Mesoscutum fuscous along anterior margin (Fig. 30), or with a light fuscous "T" shape (as in Fig. 31), or evenly fuscous; parapsis and axilla occasionally slightly fuscous. Scutellum usually fuscous, darkest along anterior and posterior margins. Metanotum medially fuscous. Propodeum fuscous, darker along lateral margins. Gastral tergites slightly fuscous. Aedeagus fuscous. Foreleg beyond coxa fuscous, tibia darkest; midleg beyond coxa fuscous, tarsi I-III darkest; hind leg beyond coxa fuscous, tarsi IV lighter than proximal tarsi. Base of forewing and costal cell slightly fuscous; venation of fore- and hind wings fuscous.

Host.—Reared from *Bemisia* (*tabaci* complex) and possibly *Trialeurodes*. Specimens have been reared from mixed hosts of *Bemisia* and *Trialeurodes*, with the latter most likely *T. abutiloneus* (Haldeman), the bandedwinged whitefly, or *T. vaporariorum* (Westwood), the greenhouse whitefly.

Discussion.—This species has been referred to as *E. californicus*, *E.* sp. nr. *californicus*, and *E. haldemani*. Although females of *E. eremicus* are extremely similar to those of *E. tejanus*, differences in male pigment patterns, in conjunction with reciprocal mating tests and electrophoretic analysis between populations from Arizona and California, and Texas (Hunter et al. 1996), indicate that the Arizona and California populations form a species distinct from the population in Texas.

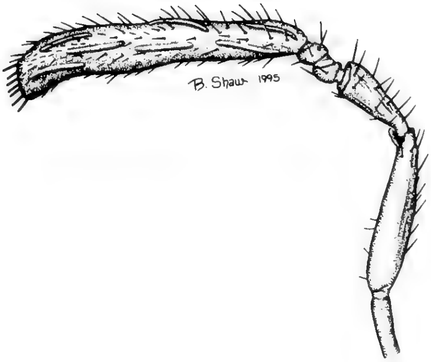
Eretmocerus eremicus is the most common naturally occurring parasite of *Bemisia* (*tabaci* complex) in the desert areas of Arizona and California. This species possibly parasitizes *Trialeurodes abutiloneus* (Haldeman), which can be sympatric with *Bemisia* in those areas. Headrick et al. (1995, 1996) described the behavior of *E. eremicus*.

Etymology.—From Latin *eremicus*, meaning "of the desert".

Holotype.—♀ mounted in balsam on a slide labelled, "Loc Phoenix/Arizona/Date III 1991/Host Bemisia/tabaci/Det GB 1991/On Gossypium/hirsutum" "Name Eretmocerus/♀/spm 1/?USNM/Det Rose 1991/Coll G. Butler/No. GB-3/Corr. Rose/Noyes 91". Deposited in USNM.

Paratypes.—**USA:** same data as holotype (3 ♀ and 3 ♂ mounted in balsam, 19 ♀ and 7 ♂ mounted in Hoyer's); Texas, Hidalgo Co., Mission Biological Control Laboratory, F_3 lab culture, M94001, original material: USA: California, Imperial Co., Brawley, K. Hoelmer, 6.i.1994, ex: *Bemisia tabaci*, on: okra (4 ♀ and 2 ♂ mounted in balsam, 7 ♀ and 4 ♂ card-mounted). Paratypes deposited with BMNH, MJR, TAMU, UCR, and USNM.

Other specimens examined.—**USA: Arizona:** Maricopa Co., Phoenix, greenhouse, 23.iv.1992, *Bemisia tabaci* on collards, O. Minkenberg (2 ♀, 5 ♂); Pima Co., Tucson, 21.x.1991, *Bemisia tabaci* on cotton, O. Minkenberg (10 ♀, 10 ♂); Tucson, greenhouse, 11.vi.1993, *Bemisia* sp. on pointsettia, O. Minkenberg (6 ♀, 13 ♂); **California**: Imperial Co., 16.xi.1992, *Bemisia* sp., T. Perring (2 ♀, 3 ♂, UCR); Bard, 7.vi.1993, *Bemisia* sp. on *Cucurbita* sp., K. Hoelmer (16 ♀, 13 ♂); Brawley, 29.xi.1982, *Bemisia tabaci*, cotton, Kramer & Forrester (11 ♀, 7 ♂); Brawley, 8.v.1982, *Bemisia* & *Trialeurodes* on lantana, G. Butler (16 ♀, 12 ♂); Brawley, 21.viii.1982, *Bemisia tabaci* on cotton, Rose (10 ♀, 10 ♂); Brawley, 29.xi.1983, *Bemisia tabaci*, cotton, Kramer & Forrester (5 ♀, 2 ♂); Brawley, 23.x.1984, *Bemisia tabaci*, bindweed, D. Meyerdirk (19 ♀, 3 ♂); Brawley, USDA, 13.ix.1993, kenaf, Rose & Pickett (5 ♀, 4 ♂); Brawley, 8.v.1995, *Bemisia argentifolii* on melon in refuge, M. Rose (10 ♀); Brawley, Legion Rd./Hwy. 86, 11.i.1995, W. Roltsch, *Bemisia argentifolii* on kenaf (19 ♀, 1 ♂); Brawley, Legion Rd./Hwy. 86, 20.iv.1995, *Bemisia argentifolii* on eggplant, W. Roltsch (18 ♀); Brawley, Legion Rd./Hwy. 86, 18.v.1995, W. Roltsch, *Bemisia argentifolii* on cantaloupe (3 ♀); Brawley, Legion Rd./Hwy. 86, 22.v.1995, *Bemisia argentifolii* on sunflower, W. Roltsch (14 ♀, 1 ♂); Brawley, Legion Rd./Hwy. 86, 13.vi.1995, W. Roltsch, *Bemisia argentifolii* on collard (14 ♀, 1 ♂); Brawley, Legion Rd./Hwy. 86, 19.vii.1995, W. Roltsch, *Bemisia argentifolii* on cotton (9 ♀); Brawley, Legion Rd./Hwy. 86, 21.viii.1995, W. Roltsch, *Bemisia argentifolii* on cotton (24 ♀); El Centro, Desert Trails RV Park, 1.ii.1993, *Bemisia* on cotton, M. Rose (3 ♀, 1 ♂); El Centro, Desert Trails RV Park, 1.ii.1993, *Bemisia* on *Hibiscus*, Rose & Pickett (12 ♀, 11 ♂); Holtville, 13.ix.1993, *Bemisia* on sunflower, M. Rose (32 ♀, 105 ♂); nr. Holtville, CDFA-Bornt's, 13.ix.1993, *Bemisia* on sunflower, Rose, Pickett, & Roltsch (33 ♀, 18 ♂); Kern Co., Bakersfield, 8.x.1992, *Trialeurodes abutilonea*? on cotton, J. Ball (2 ♀); Bakersfield, 1.ix.1993, *Bemisia tabaci* on eggplant, J. Ball (1 ♀); Bakersfield, 1.x.1993, *Bemisia tabaci* on lantana, J. Ball (1 ♀, 1 ♂); Bakersfield, 29.vi.1994, *Bemisia* on lantana, J. C. Ball (3 ♀); Bakersfield, 16.viii.1994, *Bemisia* on lantana, J. Ball (6



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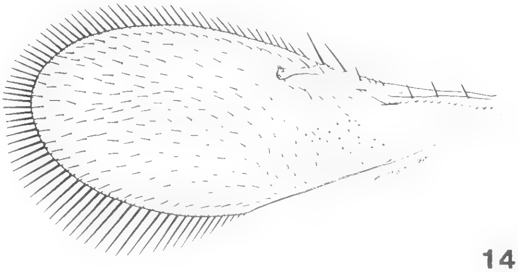

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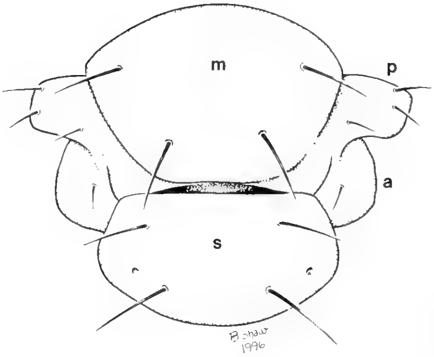

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Figs. 13–15. *Eretmocerus furuhashii*. 13, ♀ antenna. 14, ♀ forewing. 15, ♀ mesonotum. a = axilla, m = mesoscutum, p = parapsis, s = scutellum.

♀, 8 ♂); Bakersfield, 17.viii.1994, *Bemisia* on okra, J. Ball (6 ♀, 2 ♂); Bakersfield, 7.ix.1994, *Bemisia* on fruitless mulberry, J. Ball (2 ♀, 1 ♂); Bakersfield, 8.ix.1994, *Bemisia* on lantana, Joe Ball (1 ♂). All specimens from MJR unless noted otherwise.

Eretmocerus furuhashii Rose and Zolnerowich
(Figs. 13–15, 31)

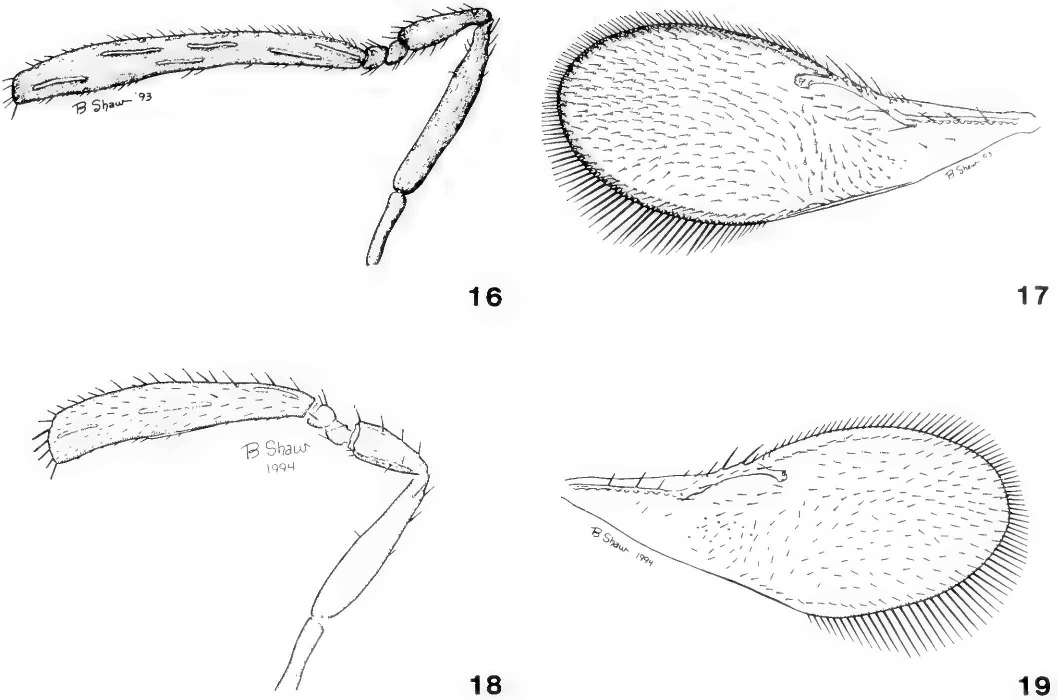
Eretmocerus furuhashii Rose and Zolnerowich, 1994: 286 [NSM, examined]

Type material.—Holotype ♀ mounted in balsam on a slide labelled, "Name Eretmocerus/furuhashii/sp.nov./Det 19/Coll M. Rose/No./Corr." "Loc Japan:/Shizuoka, Kochi/Date VIII.1979/Host Parabemisia/myricae (Kuwana)/Det 19/On Morus."

There are an additional 198 paratypes from a number of localities in California and Japan mounted in balsam and Hoyer's on a number of slides. These are deposited with BMNH, HU, MJR, NSM, TAMU, and USNM.

Diagnosis.—Females of *E. furuhashii* can be distinguished by the deflexed apex of the club (Fig. 13), mesoscutum with 4 setae, and each parapsis with 3 setae (Fig. 15). It is most similar to *E. debachi*, which differs in having a shorter club (Fig. 8) and only 2 setae on each parapsis. *Eretmocerus joeballi* can have the apex of the club slightly deflexed (Fig. 18) but differs in having 6 setae on the mesoscutum.

Males of *E. furuhashii* have each parapsis with 3 setae, a light fuscous "T" shape on the mesoscutum, and the lateral areas of the scutellum are unpigmented (Fig. 31). Males of *E. debachi* differ in having each parapsis with 2 setae, a dark fuscous "T" shape on the mesoscutum, and the scutellum is completely fuscous (Fig. 29).



Figs. 16–19. *Eretmocerus haldemani.* 16, ♀ antenna. 17, ♀ forewing. 18–19, *E. joeballi.* 18, ♀ antenna. 19, ♀ forewing.

Host.—Reared from *Parabemisia myricae*, the bayberry whitefly.

Discussion.—The description of *E. furuhashii* was based on specimens reared from *Parabemisia myricae* collected on mulberry in Japan and citrus in southern California (Rose and Zolnerowich 1994). This species was introduced to California in 1979 and was established in citrus groves in Orange, Riverside, and Ventura counties prior to the rapid distribution of *E. debachi* (Rose and DeBach 1991–1992). No recent evidence of *E. furuhashii* has been found in southern California, but displacement may not be complete in all areas of citriculture.

Eretmocerus haldemani Howard
(Figs. 16–17)

Eretmocerus haldemani Howard, 1908: 65 [USNM, examined].

Type material.—Lectotype here designated, ♀ mounted in balsam on a slide labelled, "Morrill No. 509/? holotype/Type/No. 11708/U.S.N.M." "Eretmocerus n.sp./♀/haldemani/How."

An additional slide bears two ♂ specimens, labelled "Morrill No. 509/Type/NO. 11708/U.S.N.M." "Eretmocerus/nsp. ♂/haldemani How." These are designated as paralectotypes.

Diagnosis.—Females of *E. haldemani* can be distinguished by the extremely elongate club that is 7.5–8.3× as long as wide (Fig. 16), the elongate scape that is 6.9× as long as wide, and the elongate midbasitarsus that is 8.5× as long as wide. It is most similar to *E. corni*, which has an elongate club that is only 5.9–7× as long as wide, and the scape is only 4.9× as long as wide (Fig. 6).

Males of *Eretmocerus haldemani* are very similar to those of *E. illinoisensis.* Males of these species cannot be diagnosed or separated based on the poor condition of specimens available for study.

Female.—Length, body color, sculpture, and setation could not be accurately determined from the available slide-mounted specimen. Wings hyaline.

Antenna (Fig. 16) with radicle 4.2× as long as wide; scape 6.9× as long as wide, 2.5× length of radicle, 1.8× length of pedicel, 0.6× length of club; pedicel 3.6× as long as wide, 1.4× length of radicle; 0.5× length of scape, 0.3× length of club. Funicle I triangular, 1.2× as long as wide; funicle II subquadrate. Club elongate, apex truncate, 7.5–8.3× as long as wide, 1.7× length of scape, 3.2× length of pedicel. Antennal ratio 1:2.5:1.3:4.4.

Mesoscutum trapezoidal and with 6 setae. Parapsis with 2 setae; axilla with 1 seta. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae than anterior setae.

Forewing (Fig. 17) 2.7× as long as wide at width I, 2.4× as long as maximum width of disc. Longest anterior alary fringe 0.09× width of disc, longest posterior alary fringe 0.25× width of disc. Base of wing with 1–2 setae, distal portion of costal cell with 4–5 setae. Marginal vein with 3 long setae, 14–16 setae between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 16 tubercles on ventral surface of wing near posterior end of linea calva; a group of 44–48 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 221 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 2.4:1:1.

Hind wing 7× as long as wide, with 13–14 setae in center.

Male.—Body color could not be accurately determined from available slide-mounted specimens. Foretarsi and mid- and hind tarsi IV slightly fuscous; mid- and hind tarsi I–III fuscous. Base of costal cell and venation of forewing fuscous.

Host.—Reared from *Aleuroplatus coronata* (Quaintance), the crown whitefly.

Discussion.—Howard (1908) described *E. haldemani* from one female and one male reared from *Aleuroplatus coronata* (Quaintance) collected by E. M. Ehrhorn in Berkeley, California. No collection dates are given in the literature or on the type slides. Although Howard stated that he described this species from one female and one male, the two slides bearing red USNM type labels bear one female and two males, respectively. Despite this discrepancy we accept the slides with the USNM type labels as being Howard's type specimens. No host plant was recorded, but *A. coronata* is common on *Quercus* in northern California.

Numerous specimens of *Eretmocerus* held in collections in the U.S. and abroad have been erroneously identified as *E. haldemani*. M. Rose, K. Hoelmer (USDA/APHIS), and C. Pickett and R. Gill (CDFA) have made numerous unsuccessful attempts over the past 15 years to rear specimens of *Eretmocerus* from *Aleuroplatus coronata* collected on oaks in Berkeley, California.

Eretmocerus illinoisensis Dozier

Eretmocerus illinoisensis Dozier, 1932: 114 [INHS, examined].

Type material.—Holotype ♂ mounted in balsam on a slide labelled "Eretmocerus/illinoisensis/♂ Dozier/Swept from veg-/etation in bed of/creek./Elizabethtown, Ill./Aug. 5-1932/H.L. Dozier" "Eretmocerus/illinoisensis/Dozier/SL.12934 I.N.H.S./Type No." "HOLOTYPE/Eretmocerus/illinoisensis/DOZIER" [on underside of slide].

There are two additional ♂ paratype slides labelled "Eretmocerus/illinoisensis/♂ Dozier/Swept from veg-/etation in bed of/creek./Mounted in Euparol/Elizabethtown, Ill./Aug. 5-1932/H.L. Dozier" "Eretmocerus/illinoisensis/Dozier/SL. 12935/Paratype ♂ I.N.H.S./No." "PARATYPE/Eretmocerus/illinoisensis/DOZIER" [on underside of slide], and "Eretmocerus/illinoisensis/♂ Dozier/Swept from veg-/etation in bed of-/creek./Elizabethtown, Ill./Aug. 5-1932/H.L. Dozier" "Eretmocerus/illinoisensis/Dozier/Paratype ♂/No. U.S.N.M."

Discussion.—Dozier's (1932) description of *E. illinoisensis* was based on a series of six male specimens collected by sweeping weeds and grasses in a creek bed near Elizabethtown, Illinois. We were able to locate only the holotype and two paratypes. Females are unknown, and Compere (1936) was unable to include this species in his key. As there are no host records, future association with female specimens is problematic. *Eretmocerus illinoisensis* is very similar to males of *E. haldemani* and cannot be diagnosed or separated based on the poor condition of specimens available for study.

Eretmocerus joeballi Rose and Zolnerowich, new species

(Figs. 18–19)

Diagnosis.—Females of *E. joeballi* can be distinguished by the slightly deflexed apex of the club (Fig. 18), 6 setae on the mesoscutum, and the ovipositor is 1.5× the length of the club and 1.3× the length of the midtibia. It is most similar to *Eretmocerus debachi* and *E. furuhashii*, which differ by having only 4 setae on the mesoscutum (Fig. 15).

Female.—Length of specimens mounted in Hoyer's 0.7–0.74 mm. Specimens in Hoyer's with head, body, and legs pale yellow. Portions of body with pupal exuviae attached are gold orange. Wings hyaline.

Antenna (Fig. 18) with radicle 3.8× as long as wide; scape 4.5× as long as wide, 2.1× length of radicle, 1.6× length of pedicel, 0.6× length of club; pedicel 2.0–2.3× as long as wide, equal in length to radicle; 0.5× length of scape, 0.3× length of club. Funicle I triangular, 1.2× as wide as long; funicle II 1.4× as wide as long. Club with apex slightly deflexed, 4.5–5.1× as long as wide, 1.6× length of scape, 3.2× length of pedicel. Antennal ratio 1:2.1:1:3.2.

Mesoscutum trapezoidal and with 6 setae, anterior ⅓ with strong reticulate sculpture, medially with substrigulate sculpture, laterally with elongate reticulate sculpture. Parapsis with 2 setae and strong substrigulate sculpture; axilla with 1 seta and substrigulate sculpture. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae, with substrigulate sculpture, laterally with elongate reticulate sculpture. Propodeum with faint substrigulate sculpture medially, substrigulate sculpture stronger around lateral margins. Endophragma extending to posterior margin of gastral tergite II.

Forewing (Fig. 19) 2.7× as long as wide at width I, 2.4× as long as maximum width of disc. Longest anterior alary fringe 0.14× width of disc, longest posterior alary fringe 0.3× width of disc. Base of wing usually with 2–3 setae, distal portion of costal cell with 2 setae. Marginal vein with 3 long setae, 7–13 setae between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 11–14 tubercles on ventral surface of wing near posterior end of linea calva; a group of 22–27 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 87–149 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 2.8:1.2:1.

Hind wing 6.7× as long as wide and with 1–4 setae in the center.

Gastral tergite I with substrigulate sculpture, lateral margins with broad imbricate sculpture and with stippling; gastral tergites I–VI with paired setae as follows: 1, 1, 1, 2, 2, 1. Syntergum with 4–6 setae.

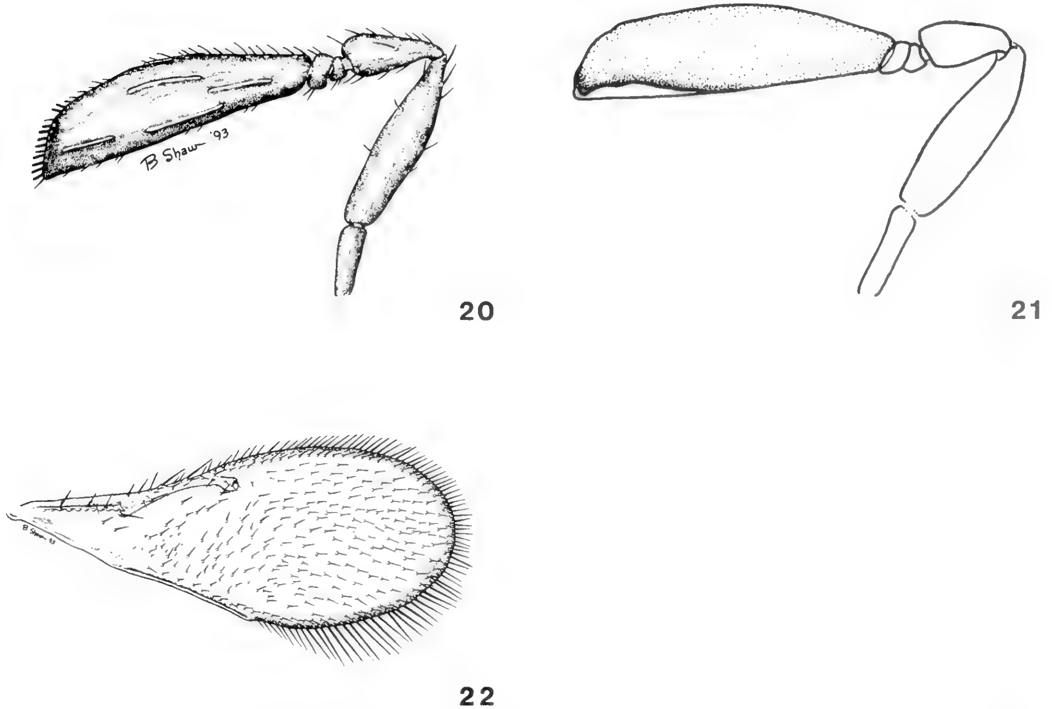
Ovipositor slightly exserted and 1.5× length of club, 4.6× length of pedicel, 2.3× length of scape, 1.3× length of midtibia.

Male.—Unknown.

Host.—Reared from *Bemisia* (*tabaci* complex).

Discussion.—This uncommon species has been recovered from *Bemisia* (*tabaci* complex) on *Morus* and *Solanum* in Kern County, California. *Eretmocerus eremicus* occurs in the same area.

Etymology.—Named in honor of Joe Ball, who collected the described specimens and has contributed to biological con-



Figs. 20–22. *Eretmocerus portoricensis*. 20, ♀ antenna. 21, ♀ antenna with artifactual "parrot beak" club. 22, ♀ forewing.

trol by natural enemies in California for more than 35 years.

Holotype.—♀ mounted in Hoyer's on a slide labelled, "Name Eretmocerus x/joeballi Rose +/Zolnerowich 96/2 ♀♀/Det. Rose+Zoln. 1995/Coll. J. C. Ball/No. 93-XI 22/Corr." "Loc Bakersfield, CA/Kern Co./Date Oct. 1 1993/Host Bemisia Tabaci/Det 19/On Mulberry?" There are two ♀ mounted on this slide. The holotype is the uppermost specimen and delimited by red ink. The second specimen on the slide is desigated as a paratype. Deposited in USNM.

Paratypes.—**USA**: same data as holotype (2 ♀ mounted in Hoyer's); **California**: Kern Co., Bakersfield, 1.ix.1993, *Bemisia tabaci* on nightshade (1 ♀ mounted in Hoyer's); Bakersfield, 7.ix.1994, *Bemisia* on fruitless mulberry, J. Ball (1 ♀ mounted in Hoyer's). Paratypes deposited with MJR and TAMU.

Eretmocerus portoricensis Dozier
(Figs. 20–22)

Eretmocerus portoricensis Dozier, 1932: 115 [USNM, examined].

Type material.—Lectotype here designated, ♀ mounted in Hoyer's on a slide labelled, "Eretmocerus/portoricensis/Dozier/Reared from Aleu-/rothrixus flocco-/sus on "Almacigo"/Bayamon, P Rico/Jan. 21-1925/H.L. Dozier" "Eretmocerus/portoricensis/Dozier/♀/Type. No. 44825 U.S.N.M." There are 13 ♀ specimens mounted on the slide. The lectotype is the specimen closest to the bottom of the slide, and faces the top edge of the slide. It is partially circled with black ink. The remaining specimens on the slide are designated as paralectotypes.

An additional slide labelled "Eretmocerus/californicus How./det Gahan/Reared from/Aleurothrixus/floccosus Mask./on Almacigo/Bayamon, P.R./Jan. 21-1925/H. L.

Dozier" "Eretmocerus/portoricensis/Dozier/Para//Type No. 44825 U.S.N.M." has 19 ♀ specimens mounted on it. These are also designated as paralectotypes.

We are unable to locate the other four slides that Dozier cited in his original description.

Diagnosis.—Females of *E. portoricensis* can be distinguished by the shape of the club, which is strongly convex dorsally and straight ventrally (Fig. 20). The shape of this club is unlike that of any other described species in the U.S.

Female.—Length of specimens mounted in Hoyer's 0.75–0.89 mm. Type series mounted in balsam with body yellow, legs slightly paler. Specimens in Hoyer's with body pale yellow. Wings hyaline.

Face and occiput with transverse substrigulate sculpture, lower face with substrigulate sculpture curving downward, interscrobal area vertically substrigulate. Antenna (Fig. 20) with radicle 3.8× as long as wide; scape 3.5× as long as wide, 2.1× length of radicle and pedicel, 0.7× length of club; pedicel 2.2× as long as wide, equal in length to radicle, 0.5× length of scape, 0.3× length of club. Funicle I triangular, as wide as long; funicle II 1.6× as wide as long. Club with apex curved, 3.2–3.8× as long as wide, 1.5× length of scape, 3.1× length of pedicel. Antennal ratio 1:2.1:1:3.1.

Mesoscutum trapezoidal and with 6 setae, anterior ¼ with reticulate sculpture, laterally with faint elongate reticulate sculpture, remainder with substrigulate sculpture. Parapsis with 2 setae and faint reticulate to substrigulate sculpture along lateral margins; axilla with 1 seta and sculpture similar to parapsis. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae, with substrigulate sculpture medially and reticulate sculpture laterally. Propodeum with transverse striations medially and reticulate sculpture laterally. Endophragma broad, extending from posterior ¼ of gastral tergite I to anterior margin of gastral tergite II.

Forewing (Fig. 22) 2.7× as long as wide at width I, 2.3× as long as maximum width of disc. Longest anterior alary fringe 0.1× width of disc, longest posterior alary fringe 0.2× width of disc. Base of wing usually with 2 setae, occasionally 1–3, often with 1 seta enlarged and reaching submarginal vein, distal portion of costal cell usually with 2–3, occasionally 1–4, setae. Marginal vein with 3 long setae, 10–13 setae between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 10–16 tubercles on ventral surface of wing near posterior end of linea calva; a group of 18–30 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 139–191 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 3:1.3:1.

Hind-wing 6.9× as long as wide and with 0–2 setae in center.

Gastral tergite I reticulate anteriorly and anterolaterally; lateral margins of tergites imbricate with rows of stippling; tergites I-VI with paired setae as follows: 1, 1–2, 1–2, 1–2, 2–4, 2–4. Syntergum with 4 setae.

Ovipositor slightly exserted, 1.2× length of club, 3.6× length of pedicel, 1.7× length of scape, equal in length to midtibia.

Male.—Unknown.

Host.—Reared from *Aleurothrixus floccosus* (Maskell), the woolly whitefly.

Discussion.—Dozier's description was based on a series of 45 female specimens on three slides reared from *Aleurothrixus floccosus* (Maskell) on *Bursera* (= *Elaphrium*) *simaruba* (L.) taken at Bayamon, Puerto Rico, and 18 female specimens on three slides reared from *A. floccosus* on *Guaiacum* (= *Guajacum*) *officinale* L. collected at Central Aguire, Puerto Rico.

Gahan originally identified Dozier's specimens as *E. californicus* in 1925. Dozier (1932) later compared his specimens from *A. floccosus* with the type material of *E. californicus* at the USNM and concluded the species were distinct. The antennal club of *E. portoricensis* was described with "the apex shaped somewhat like a parrot's beak", but this distinctive shape is artifactual. The apex of the club is a blunt curve, but the shriveled contents of the club can withdraw from the cuticle to create a beaked appearance (Fig. 21). This artifact has not been observed in other species.

Eretmocerus portoricensis has been reared from *A. floccosus* collected on citrus in Peru. This material probably resulted from the importation of parasites of *A. floccosus* from Florida in 1957 (Ebeling 1957).

Other specimens examined.—**USA**: **Florida**: Broward Co., Fort Lauderdale, ix.10.80, *Aleurothrixus floccosus* on citrus, R. Dowell, No. R80-52 (13 ♀); Fort Lauderdale, 1982, *Aleurothrixus floccosus*, C. R. Thompson (7 ♀); Hollywood, ii.2.80, *Aleurothrixus floccosus* on citrus, Wm. Gregory., No. R80-1-2, No. R80-1-3 (21 ♀); Hollywood, viii.31.81, *Aleurothrixus floccosus* on citrus, Wm. Gregory, No. R81-45 (6 ♀); Oakland Park, i.3.80, *Aleurothrixus floccosus* on citrus, B. Gregory, No. R80-1-11 (3 ♀); Manatee Co., Anna Maria Island, 20.ii.1993, *Aleurothrixus floccosus* (Mask.) on sea grape, Rose & Kring (7 ♀); **PERU**: Lima: ix.1974, *Aleurothrixus floccosus* on citrus, J. S. Torres (9 ♀). All specimens from MJR.

Eretmocerus staufferi Rose and Zolnerowich, new species

(Figs. 23-25, 32)

Diagnosis.—Females of *E. staufferi* can be distinguished by the extremely elongate club that is 8.2–9.1× as long as wide (Fig. 23) and the distinct brown or brown orange mesosoma (Fig. 25). No other species has such an elongate club or the mesosoma brown orange.

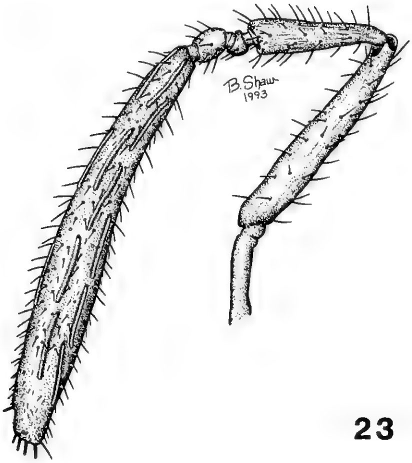
Males also have the distinct brown or brown orange mesosoma (Fig. 32) that is unlike that of any other species of *Eretmocerus*.

Female.—Length of critical point-dried specimens 0.53–0.63 mm. Critical point-dried material with vertex orange red; face and gena paler and more yellow. Antenna colored as face. Mesosoma brown orange. Gaster yellow orange. Legs varying from testaceous to tan, tarsi slighter darker than tibiae. Wings slightly fuscous. Specimens mounted in Hoyer's usually with mesoscutum and scutellum pale medially (Fig. 25).

Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate. Antenna (Fig. 23) with radicle 4.3× as long as wide; scape 5.7× as long as wide, 2.5× length of radicle, 1.8× length of pedicel, 0.6× length of club; pedicel 3.3× as long as wide, 1.4× length of radicle, 0.6× length of scape, 0.3× length of club. Funicle I triangular, 1.2× as long as wide; funicle II 0.9× as long as wide. Club 8.2–9.1× as long as wide, 1.8× length of scape, 3.3× length of pedicel. Antennal ratio 1:2.5:1.4:4.5.

Mesoscutum trapezoidal, usually with 6 setae but supernumerary setae common, anterior ⅓–½ with strong reticulate sculpture, narrow median area with substrigulate sculpture, remainder with elongate reticulate sculpture. Parapsis with 2 setae and substrigulate sculpture; axilla with 1 seta and substrigulate sculpture. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae, with strong substrigulate sculpture, medially varying from reticulate to substrigulate, posterolateral margins varying from reticulate to substrigulate. Propodeum with substrigulate sculpture medially, laterally with strong substrigulate sculpture, remainder smooth or slightly substrigulate. Endophragma extending to posterior margin of gastral tergite I.

Forewing (Fig. 24) 3× as long as wide at width I, 2.7× as long as maximum width of disc. Longest anterior alary fringe 0.17× width of disc, longest posterior alary fringe 0.3× width of disc. Base of wing usually with 3–4, occasionally 2–6, setae, distal portion of costal cell usually with 2–3, occasionally 1–4, setae. Marginal vein with 3 long setae, 8–12 setae between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 10–17 tubercles on ventral surface of wing near posterior



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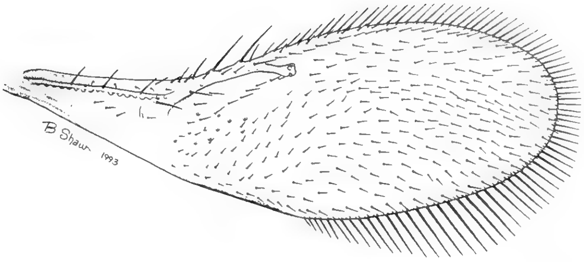

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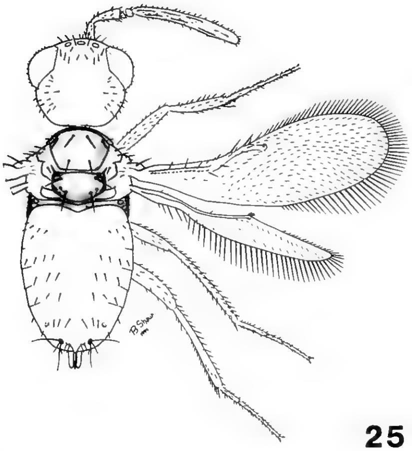

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Figs. 23–25. *Eretmocerus staufferi*. 23, ♀ antenna. 24, ♀ forewing. 25, ♀ habitus.

end of linea calva; a group of 33–39 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 126–223 setae in disc point to distal apex of wing. Ratio of submarginal: marginal:stigmal veins 2.9:1.2:1.

Hind wing 7× as long as wide and with 16–38 setae in the center.

Gastral tergite I with substrigulate sculpture, lateral margins with broad imbricate sculpture and with stippling; gastral tergites I-VI with paired setae as follows: 2–6, 3–7, 3–7, 4–8, 4–10, 3–4. Syntergum with 5–10 setae.

Ovipositor slightly exserted and 0.8× length of club, 2.6× length of pedicel, 1.4× length of scape, 0.9× length of midtibia.

Male.—Specimens mounted in Hoyer's with head amber; eyes bright red. Radicle and scape slightly fuscous, scape darker in distal ⅓; pedicel dark fuscous; multiporous plate sensilla fuscous. Pronotum fuscous. Mesoscutum fuscous, darkest anteriorly (Fig. 32). Parapsis, axilla, tegula, and scutellum fuscous, scutellum darkest along margins. Metanotum fuscous, darkest medially. Propodeum fuscous, darkest along lateral margins. Gaster slightly fuscous, with gastral tergite I darker medially. Aedeagus fuscous. Foreleg except coxa and trochanter slightly fuscous; midtrochanter, femur, and tibia slightly fuscous, tarsi darker; hind leg slightly fuscous, femur and proximal ⅔ of tibia darkest. Fore- and hind wings slightly fuscous.

Host.—Reared from *Bemisia* (*tabaci* complex) and *Trialeurodes abutiloneus* (Haldeman), the bandedwinged whitefly.

Discussion.—There were only two male specimens in the original collections of *E. staufferi*. Males are not common in laboratory cultures and are not needed for production of females. This distinct thelytokous species is being evaluated for its biological control potential in California, Texas, and the Netherlands.

Etymology.—Named in honor of R. S. Stauffer, who found this species attacking *Bemisia* (*tabaci* complex) and *T. abutiloneus* at TAMU.

Holotype.—♀ mounted in balsam on a slide labelled, "USA: Texas/Hidalgo Co./Mission/Biological/Control/Laboratory/F_2 lab culture/M94002" "original/material:/USA: Texas/Brazos Co./College Station/10.xii.1993" "Rose & Stauffer/ex: Bemisia/tabaci/on: tomato". Deposited in USNM.

Paratypes.—**USA**: same data as holotype (6 ♀ mounted in balsam, 15 ♀ card-mounted); **Texas**: College Station, glasshouse, TAMU, 29.xi.1993, Host *B. tabaci* & *T. abutiloneus*, On *Lycopersicon cheesmanii*, R. S. Stauffer (11 ♀, 2 ♂ mounted in Hoyer's). Paratypes deposited with BMNH, MJR, TAMU, UCR, and USNM.

Other specimens examined.—**USA: Texas**: Bexar Co., San Antonio, San Antonio Botanical Garden greenhouse, 11.vii.1991, *Bemisia tabaci* on *Hibiscus lasiocarpus*, C. Moomaw (1 ♀); Brazos Co., College Station, Crop Biosciences Bldg. GH, TAMU, 18–22.xi.1993, *Bemisia tabaci* on tomato, R. S. Stauffer (20 ♀); College Station, TAMU culture, 7.x.1994, *Bemisia tabaci* on *Hibiscus*, M. Hunter (14 ♀, 7 ♂); College Station, TAMU Biotech Greenhouse, 7.x.1994, *Bemisia* on tomato, M. Hunter (1 ♂); College Station, TAMU BC Labs, 4.ii.1995, *Bemisia* on *Hibiscus*, M. Hunter (1 ♂). All specimens from MJR.

Eretmocerus tejanus Rose and Zolnerowich, new species

(Figs. 26-28, 33)

Diagnosis.—Females of *E. tejanus* can be distinguished by the club that is 6.2–7.1× as long as wide (Fig. 26), pedicel that is 3–3.7× as long as wide and 0.29–0.36× as long as the club, mesoscutum with 6 setae, and gastral tergite II usually with 2 pairs, but occasionally 1 pair, of lateral setae (Fig. 28).

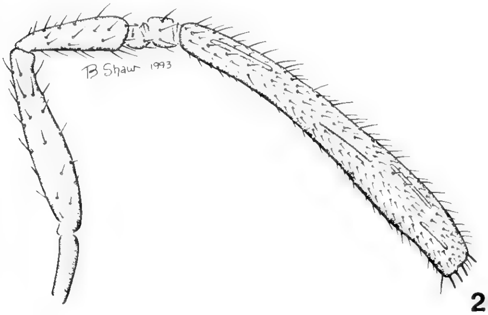
Females of *E. tejanus* are very similar to *E. corni* and *E. eremicus*. Females of *E. corni* have the pedicel 2.4–3.1× as long as wide and 0.25–0.30× as long as the club (Fig. 6), and have not been reliably recorded from *Bemisia* (*tabaci* complex). *Eretmocerus eremicus* has the anterior alary fringe of the forewing slightly longer (Fig. 11), and gastral tergite II usually has 1 pair, but occasionally 2 pairs, of lateral setae (Fig. 12).

Males of *E. tejanus* can be distinguished by the longitudinal fuscous bands on the mesocutum (Fig. 33). Males of *E. corni* lack longitudinal fuscous bands on the mesocutum, and males of *E. eremicus* have the mesoscutum fuscous along the anterior margin (Fig. 30), or with a light fuscous "T" shape (as in Fig. 31), or evenly fuscous.

Female.—Length of critical point-dried specimens 0.44–0.59 mm. Head and body varying from white testaceous to tan yellow, with darker specimens having the vertex orange yellow. Eyes grey red, ocelli clear. Legs testaceous, tarsi occasionally slightly darker than tibiae. Wings hyaline.

Specimens mounted in Hoyer's with head amber and body pale yellow.

Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate. Antenna (Fig. 26) with radi-



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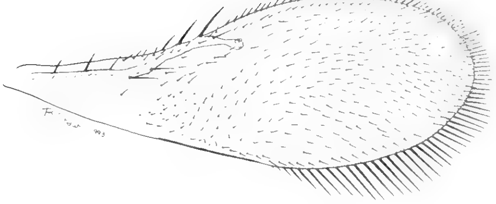

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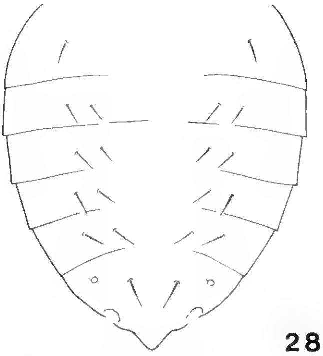

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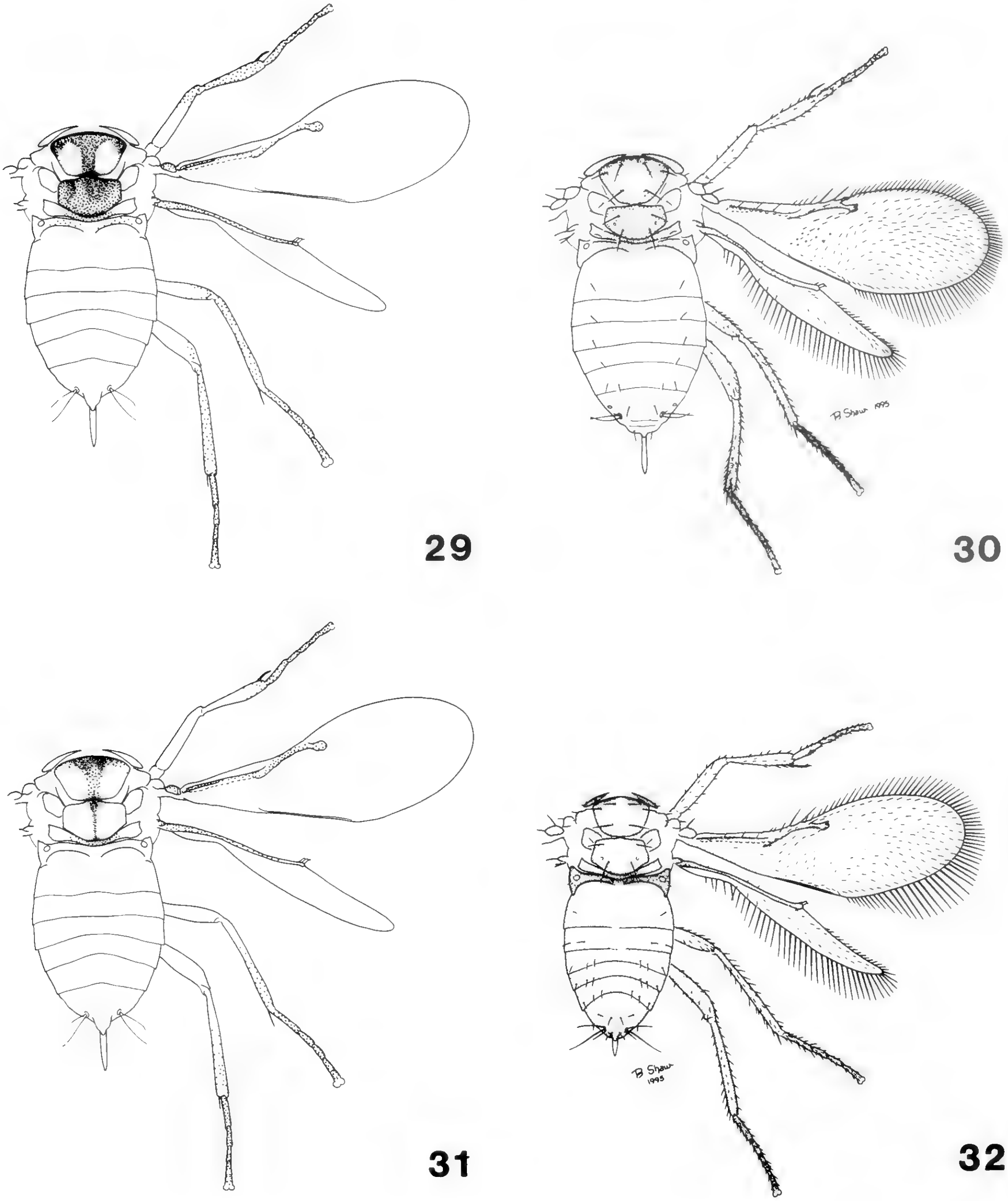
Figs. 26–28. *Eretmocerus tejanus*. 26, ♀ antenna. 27, ♀ forewing. 28, ♀ gaster.

cle 4.2× as long as wide; scape 5× as long as wide, 2.1× length of radicle, 1.6× length of pedicel, 0.6× length of club; pedicel 3–3.7× as long as wide, 1.4× length of radicle; 0.6× length of scape, 0.29–0.36× length of club. Funicle I triangular, 1.1× as wide as long; funicle II subquadrate. Club 6.2–7.1× as long as wide, 1.8× length of scape, 2.8× length of pedicel. Antennal ratio 1:2.2:1.4:3.5.

Mesoscutum trapezoidal and with 6 setae, anterior ¼ with reticulate sculpture, substrigulate sculpture in narrow triangular medial area, remainder with elongate reticulate sculpture. Parapsis with 2 setae, with fine reticulate sculpture proximally and substrigulate sculpture distally; axilla with 1 seta and substrigulate sculpture. Scutellum with 4 setae and 2 placoid sensilla lateral to and closer to posterior setae, and elongate substrigulate sculpture. Propodeum with faint substrigulate sculpture medially and around spiracles. Endophragma extending into gastral tergite II.

Forewing (Fig. 27) 2.9× as long as wide at width I, 2.6× as long as maximum width of disc. Longest anterior alary fringe 0.13× width of disc, longest posterior alary fringe 0.28× width of disc. Base of wing usually with 1 seta, occasionally 1–3, distal portion of costal cell usually with 2–4, occasionally 1–4, setae. Marginal vein with 3 long setae, 9–12 setae, occasionally 9–14, between marginal vein and linea calva. Linea calva closed posteriorly by setae, with 10–15 tubercles on ventral surface of wing near posterior end of linea calva; a group of 26–37 setae including those forming distal edge of linea calva point toward anterior margin of wing, remaining 162–208 setae in disc point to distal apex of wing. Ratio of submarginal:marginal:stigmal veins 3:1.3:1.

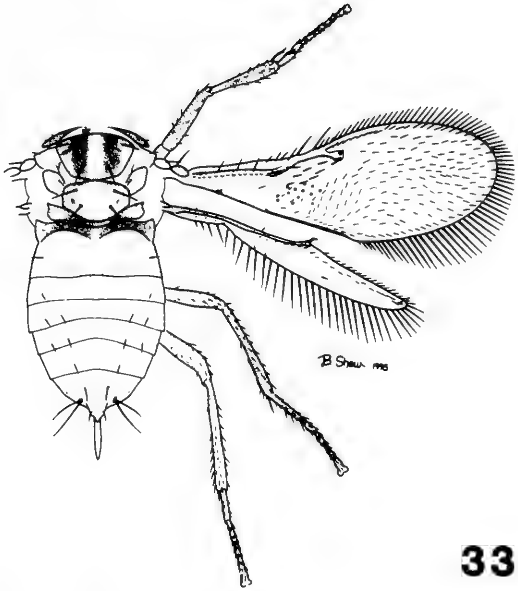
Hind wing 7.3× as long as wide and with 3–8 setae in the center.



Figs. 29–32. ♂ habitus. 29, *Eretmocerus debachi*. 30, *E. eremicus*. 31, *E. furuhashii*. 32, *E. staufferi*.

Gastral tergite I with substrigulate sculpture, smooth around lateral setae, lateral margins faintly imbricate with stippling; gastral tergites I–VI (Fig. 28) usually with paired setae as follows: 1, 2, 2, 2, 2, 1, although specimens are known with 1–2, 0–3, 2, 2–3, 2–3, 1. Syntergum with 4 setae.

Ovipositor slightly exserted, equal in length to club, 2.8× length of pedicel, 1.7× length of scape, equal in length to midtibia.



33

Fig. 33. *Eretmocerus tejanus*, ♂ habitus.

Male.—Length of critical point-dried specimens 0.43–0.51 mm. Critical point-dried specimens colored as female except pronotum brown dorsolaterally, mesoscutum with 2 sublateral longitudinal fuscous bands, pale medially and laterally (Fig. 33), scutellum slightly fuscous, foretarsi slightly darker than tibia.

Specimens mounted in Hoyer's with head amber. Radicle and scape fuscous, with scape darker at apex; pedicel dark fuscous; multiporous plate sensilla of club fuscous. Pronotum fuscous. Mesoscutum dark fuscous along anterior margin, slightly less fuscous along length of mesoscutum, medially and laterally pale, creating 2 longitudinal fuscous bands (Fig. 33). Parapsis and axilla slightly fuscous. Scutellum fuscous to slightly fuscous, usually darker along anteror and posterior margins. Metanotum slightly fuscous, darker medially. Propodeum fuscous except medially and along anterolateral margins. Gaster pale to slightly fuscous. Aedeagus brown. Foreleg except coxa fuscous; midleg except coxa pale, midtibia occasionally fuscous, midtarsi brown; hind trochanter pale to slightly fuscous, hind femur slightly fuscous, tibia darker, tarsi brown. Base of forewing and costal cell slightly fuscous; submarginal vein brown fuscous, marginal and stigmal veins slightly fuscous. Venation of hind wing brown fuscous.

Host.—Reared from *Bemisia* (*tabaci* complex).

Discussion.—*Eretmocerus tejanus* has been referred to as *E. californicus* and *E.* sp. nr. *californicus*. Although females of *E. tejanus* are extremely similar to those of *E. eremicus*, differences in male pigment patterns, in conjunction with reciprocal mating tests and electrophoretic analysis between populations from Arizona and California, and Texas (Hunter et al. 1996), indicate that the Texas population forms a species distinct from the populations in Arizona and California.

This species was one of the most common naturally occurring parasites of *Bemisia* (*tabaci* complex) in the Rio Grande Valley of south Texas prior to the 1995 Boll Weevil Eradication Program. *Eretmocerus tejanus* was not recovered from rearing samples taken during this program. Populations of this species began to appear again during the spring of 1996, approximately nine months following cessation of insecticide treatments. Sampling for this and other species of parasites in the Rio Grande Valley continues.

Eretmocerus tejanus has been released in central and southern California for control of *Bemisia* (*tabaci* complex).

Etymology.—From Spanish *Tejano*, meaning "Texan".

Holotype.—♀ mounted in balsam on a slide labelled, "USA: Texas/Hidalgo Co./Mission/Biological/Control/Laboratory/F_3 lab culture/M94003" "original/material:/USA: Texas/Hidalgo Co./Mission/18.i.1994" "J. Rodriguez/ex: Bemisia/tabaci/on: cabbage". Deposited in USNM.

Paratypes.—**USA**: same data as holotype (3 ♀ and 2 ♂ mounted in balsam, 14 ♀ and 10 ♂ card-mounted); **Texas**: Hidalgo Co., Weslaco, TAES greenhouse, xi.1990, Host *Bemisia tabaci*, On melon, B. Breene (6 ♀, 4 ♂ mounted in Hoyer's); Weslaco, 10.vi.1993, Host *Bemisia* sp., On *Brassica oleraceae* [sic], C. Moomaw (19 ♀, 15 ♂ mounted in Hoyer's). Paratypes deposited with BMNH, MJR, TAMU, UCR, and USNM.

Other specimens examined.—**Texas**: Brazos Co., College Station, TAMU, B.C. garden, 23.v.1991, *Bemisia tabaci*, C. Moomaw (1 ♀, 1 ♂); TAMU, B.C. garden, 3.vii.1991, *Bemisia tabaci* on kale, C. Moomaw (1 ♂); TAMU Green House, 6.vi.1991, *Bemisia tabaci* on squash, C. Moomaw (7 ♀, 8 ♂); Hidalgo Co., Hargill, 25.vi.1993, *Bemisia tabaci* on cabbage, Moomaw (12 ♀, 13 ♂); Hargill, 25.vi.1993, *Bemisia tabaci* on kenaf, Moomaw (14 ♀, 6 ♂); nr. Hargill, Rio Farms, 2.viii.1993, *Bemisia tabaci* on kenaf, Moomaw (8 ♀, 5 ♂); nr. Mission, Holbrook, 2.vi.1993, *Bemisia tabaci* on watermelon, Moomaw (3 ♀, 5 ♂); nr. Mission, Holbrook, 29.vi.1993, *Bemisia tabaci* on kale, Moomaw (2 ♀); nr. Mission, Holbrook farms, 26.vii.1993, *Bemisia tabaci* on pigweed, C. Moomaw (10 ♀, 8 ♂); Weslaco, 9.vii.1991, *Bemisia tabaci* on cotton, M. Rose (4 ♀, 1 ♂); Weslaco, 25.iii.1992, *B. tabaci* on cantaloupe, Moowaw (1 ♂); Weslaco, USDA-ARS, 26.iii.1992, *B. tabaci* on sunflower, Moowaw (1 ♀, 1 ♂); Weslaco, USDA-ARS, 26.iii.1992, *B. tabaci* on sunflower, Woolley (1 ♀, 1 ♂); Weslaco, USDA-ARS, 18.vii.1992, *Bemisia tabaci* on kale, Moomaw (5 ♀, 6 ♂); Weslaco, USDA-ARS test plot refuge, 18.vii.1992, *Bemisia tabaci* on kale, M. Rose & C. Moomaw (6 ♀, 3 ♂); Weslaco, USDA-ARS, 30.x.1992, *Bemisia tabaci* on kale, Moomaw (13 ♀, 9 ♂); Weslaco, Rio Grande Valley, 1.iv.1993, *Bemisia tabaci* on cabbage, M. Rose (2 ♀, 1 ♂); Weslaco, Rio Grande Valley, 1.iv.1993, *Bemisia tabaci* on collards, M. Rose (4 ♀, 7 ♂); Weslaco, TAES, 20.iv.1993, *Bemisia tabaci* on canola, Moomaw (3 ♀, 1 ♂); Weslaco, TAES-Riley, 28.vi.1993, *Bemisia tabaci* on sunflower, C. Moomaw (5 ♀, 5 ♂); Weslaco, TAES-Riley, 27.vii.1993, *Bemisia tabaci* on sunflower, Moomaw (12 ♀, 4 ♂); Weslaco, TAES-Riley, 31.vii.1993, *Bemisia tabaci* on kale, Moomaw (9 ♀, 9 ♂); Weslaco, TAES, 21.viii.1993, *Bemisia tabaci* on cotton, Moomaw (3 ♀, 5 ♂); Weslaco, Rio Grande Valley, 19.v.1994, *Bemisia tabaci* on mixed host plants, M. Rose (25 ♀, 20 ♂). All specimens from MJR.

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A REVIEW OF THE SHORE-FLY GENUS *DIPHUIA* CRESSON (DIPTERA: EPHYDRIDAE)

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Abstract.—Diphuia Cresson is reviewed to include (1) the synonymy of *D. nasalis* Wirth with *D. nitida* Sturtevant and Wheeler, (2) the description of **D. flinti, new species** (Dominican Republic: El Seibo), and (3) a cladistic analysis of the genus.

Key Words: Diptera, Ephydridae, shore flies, *Diphuia,* New World tropics, cladistics

While conducting field work on the Dominican Republic in 1995, a tiny, somewhat shiny, black shore fly of the genus *Diphuia* Cresson was discovered that is apparently associated with freshwater habitats. Other species of *Diphuia* occur along shorelines and beaches of maritime environments with brackish-water or saline habitats. Determining the identity of this species, which is less than 2.5 mm in length, has led to this review and cladistic analysis of *Diphuia.*

Diphuia is known only from the New World, mainly from subtropical and tropical zones, and has greatest diversity in the Caribbean and adjacent areas. Although comparatively common in nature, specimens are scarce in collections, probably because of the restricted distribution of the genus and the small size of specimens (2.5 mm or less). The nomenclatural history of *Diphuia* and included species, as well as other available information were included in my earlier revision (Mathis 1990) and are not repeated here except for the taxa being treated.

METHODS

The terminology and methods used in this study were explained previously (Mathis 1990). Because of the small size of specimens, study and illustration of the male terminalia required the use of a compound microscope. To better assure effective communication about structures of the male terminalia, I have adopted the terminology of other workers in Ephydridae (see references in Mathis 1986). Usage of these terms, however, should not be taken as an endorsement of them from a theoretical or morphological view over alternatives that have been proposed (Griffiths 1972, McAlpine 1981). Rather, I am deferring to tradition until the morphological issues are better resolved.

Two venational ratios are used commonly in the descriptions and are defined here for the convenience of the user (ratios are averages of three specimens).

1. Costal vein ratio: the straight line distance between the apices of veins R_{2+3} and R_{4+5}/distance between the apices of veins R_1 and R_{2+3}.
2. M vein ratio: the straight line distance along M between crossveins (dm-cu and r-m)/distance apicad of crossvein dm-cu.

The specimens used in this study are primarily in the National Museum of Natural History (USNM), Smithsonian Institution. A few, especially primary types, are in the American Museum of Natural History

(AMNH), New York. I also examined specimens from the University of Texas, Austin (UTA) collection.

The phylogenetic analysis was performed with the assistance of Hennig86 ©, a computerized algorithm that produces cladograms on the basis of parsimony. Before performing the analysis, the character data were arranged in transformation series and then polarized primarily using outgroup procedures.

Diphuia Cresson

Diphuia Cresson, 1944:4. Type species: *Diphuia anomala* Cresson, 1944, by original designation; 1946:138, 140 [note, key].—Sturtevant and Wheeler, 1954:248 [notes].—Wirth, 1956:4 [discussion of species]; 1965:737 [Nearctic catalog]; 1968:5 [Neotropical catalog].—Mathis, 1990:746–756 [revision].—Mathis and Zatwarnicki, 1995:155–156 [world catalog].

Description.—Mostly black, subshiny to shiny, microtomentum usually sparse; small shore flies, length 1.35–2.10 mm. *Head:* Wider than high; face width-to-head width ratio 0.28; frons black, mostly unicolorous, lacking distinctively colored ocellar triangle; frons wider than long, frontal length-to-width ratio 0.58; frontal vestiture variable; ocellar seta well developed, inserted slightly in front of alignment of anterior ocellus and at about the same distance apart as between posterior ocelli; pseudopostocellar setae usually well developed, length subequal to ocellar setae, proclinate, slightly divergent; 1 reclinate and 1 proclinate fronto-orbital seta present, reclinate seta inserted slightly anteromediad of proclinate seta; both inner and outer vertical setae present; ocelli arranged to form isosceles triangle, with distance between posterior ocelli larger than between anterior ocellus and either posterior ocellus. Antenna exerted; pedicel with well-developed, proclinate, dorsal seta; aristal length subequal to antennal length and bearing 4–5 dorsal rays, with basal 3 rays longer than apical 1–2, the latter subequal. Eye apparently bare of microsetulae (using a stereomicroscope). Face black in both sexes and with silvery white, microtomentose antennal grooves and with 2 lines, sometimes irregular, paralleling parafacials, these and similarly invested and colored ventral margin (microtomentum sometimes interrupted at middle) form a facial triangle that has a small microtomentose area below facial prominence; face not carinate between antennal bases but slightly, conically protrudent at middle (best seen in lateral view); ventral facial margin shallowly emarginate; face bearing 2 facial setae, the dorsal seta very slightly larger, both inserted near parafacials; parafacials densely microtomentose, silvery white; clypeus very sparsely microtomentose, black; palpus blackish brown to black; mouthparts not geniculate, labella shorter than mediproboscis. *Thorax:* Generally black, vestiture of microtomentum variable with species, although generally sparse; pleural areas lacking stripes of distinctly colored microtomentum. Chaetotaxy with mesonotal setae poorly developed except for those at posterior margin; mesonotal setulae numerous and not arranged in well-defined setal tracks; prescutellar acrostichal setae much larger than other acrostichal setulae and more widely set apart; only 1 dorsocentral seta, inserted posteriad; intra-alar setulae irregularly seriated; presutural seta well developed, length subequal to notopleural setae; 2 scutellar setae and scutellar disc with sparse, scattered setulae; postpronotal seta 1; postalar seta 1; notopleural setae 2, insertion of posterior seta elevated dorsally above anterior one; anepisternal setae 2, inserted along posterior margin; katepisternal seta well developed, conspicuous. Wing: membrane mostly hyaline to very slightly milky white; veins behind costa pale, usually yellowish to yellowish brown; vein R_{2+3} extended well beyond level of crossvein dm-cu, 2nd costal section at least 1½ times longer than 3rd section; alular marginal setulae short, less than ½ alular height.

Legs: femora black; tibiae dark basally, concolorous with femora, apices yellowish. *Abdomen:* Fifth segment of male well sclerotized, elongate, not normally visible from a dorsal view, usually retracted within 4th segment; 5th tergum and sternum of male united anteriorly to form a complete annulus. Male terminalia as follows: cercus rod shaped, bearing 1–3 conspicuously longer setae at ventral margin; surstylus well developed, well sclerotized, conspicuous, and as long or longer than cercus.

Distribution.—New World. Temperate to tropical zones, in North America along the east coast (New York south to Florida) and the Caribbean to Colombia and Ecuador in South America.

Diagnosis.—*Diphuia* can be distinguished from other genera of Hecamedini as follows (characters indicated by an asterisk (*) are autapomorphies that corroborate the monophyly of *Diphuia*): *coloration very dark, usually black; *microtomentum of head and thorax generally sparse, giving a subshiny to faintly dull appearance; facial coloration of male and females similar, lacking sexual dimorphism; face, although slightly protrudent medially (best seen in profile), not acutely pointed in lateral view; *face with silvery white microtomentose markings, antennal grooves, 2 vertical lines, ventral margin, an area below the facial prominence, and parafacials; presutural and prescutellar setae well developed; *pleural region lacking a stripe or stripes; 5th segment of male well sclerotized and its tergum moderately elongate; *5th tergum and sternum of male united anteriorly to form a complete annulus; and male genitalia with distinct, well-sclerotized, elongate surstyli.

KEY TO SPECIES GROUPS AND SPECIES OF *DIPHUIA*

1. Anepisternum with anteroventral ⅓–½ bare, shiny black, otherwise with sparse investment of whitish gray microtomentum; mesonotum sparsely invested with microtomentum, subshiny; 5th tergum of male with anterior margin even (Fig. 2); surstylus with ventral margin broadly rounded; gonite trapezoidal; aedeagus with apex bifurcate . . . . *D. nitida* Sturtevant and Wheeler
– Anepisternum almost entirely invested with whitish gray microtomentum; mesonotum moderately densely microtomentose, golden brown; 5th tergum of male shallowly or deeply emarginate (Fig. 16); surstylus truncate ventrally, pointed apically; gonite with basal half subrectangular; aedeagus not bifurcate apically 2
2. Ventral portion of face with median, vertical, densely microtomentose, silvery white stripe extended dorsad from and connected to microtomentose ventral margin; 5th tergum longer than wide, anterior margin shallowly emarginate . . . . *D. flinti*, new species
– Ventral portion of face with median, densely microtomentose, silvery to golden white spot (frequently triangular or diamond shaped) that is not directly connected with microtomentum along ventral margin; 5th tergum wider than long, anterior margin deeply emarginate, emargination V-shaped 3
3. Surstyli long and narrow, length subequal to that of cercus; gonite pointed posteroventrally; aedeagus only moderately curved apically . . . . *D. anomala* Cresson
– Surstyli moderately short and robust, length shorter than cercus; gonite with posteroventral portion broadly bifurcate; aedeagus more curved apically, point oriented anteriorly . . . . *D. zatwarnickii* Mathis

Diphuia nitida Sturtevant and Wheeler (Figs. 1–8)

Diphuia nitida Sturtevant and Wheeler, 1954:248.—Wirth, 1965:737 [Nearctic catalog].—Mathis, 1990:754 [revision].—Mathis and Zatwarnicki, 1995: 156 [world catalog].

Diphuia nasalis Wirth, 1956:3; 1968:5 [Neotropical catalog].—Mathis, 1990: 750–754 [revision].—Mathis and Zatwarnicki, 1995:156 [world catalog]. New Synonym.

Description.-Small shore flies, length 1.35 to 1.75 mm.

Head: Frons sparsely invested with fine brownish microtomentum, microtomentum becoming sparser or lacking on 2 small areas laterad of posterior ocelli, 2 spots along the anterior margin, and sometimes a small spot in front of the anterior ocellus. Ventral portion of face with median, densely microtomentose, silvery to golden white spot (frequently triangular or diamond shaped) that is not directly connected with microtomentum along ventral margin.

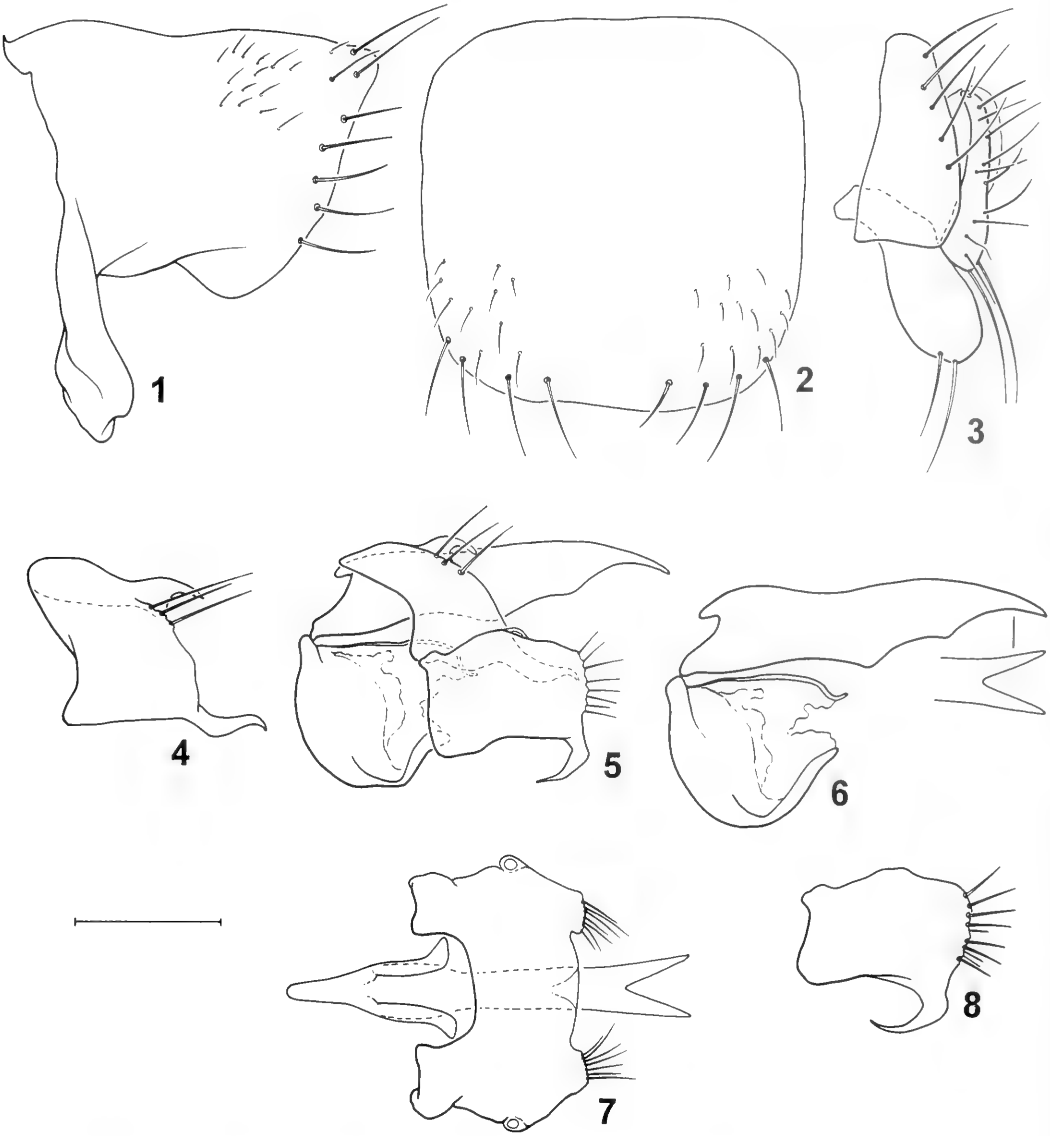
Thorax: Mesonotum sparsely invested with fine brownish to golden brown microtomentum, mostly subshiny to shiny; anepisternum with anteroventral ⅓ to ½ bare of microtomentum, shiny, posterodorsal portion invested with fine, grayish microtomentum. Wing with costal vein ratio 0.58; M vein ratio 0.40.

Abdomen: 5th tergum with anterior margin essentially straight, at most very shallowly arched anteriorly (Fig. 2); 5th sternum undivided, as a narrow band connected dorsally with anteroventral portion of 5th tergum (Fig. 1). Male terminalia (Figs. 3–8) as follows: epandrium narrow in lateral view, much higher than wide (Fig. 3); surstylus as long as cercus but almost twice its width, broadly rounded apically (Fig. 3); gonite in lateral view parallelogram-shaped, posterior angles produced into pointed processes, posteroventral process sinuous (Figs. 4–5); aedeagal apodeme rounded anteroventrally (Figs. 4–5); aedeagus acutely pointed apically, in dorsal or ventral view bifurcate apically (Figs. 4–5); hypandrium in ventral view wider than long, anterior margin shallowly arched anteriorly (Figs. 5, 7–8).

Type material.—The holotype ♀ of *D. nitida* is labeled "Dougl[a]s[t]on[,] L[ong]. I[sland]., N[ew]. Y[ork].[,] Au[gust]. 17, [19]52/HOLOTYPE Diphuia nitida Stvt & Whlr [pink]/TYPE 6695 [dark pink; number handwritten]." The holotype is point mounted, is in poor condition (the antennae and several setae are missing and the left side of the body and wings are covered partially with glue), and is deposited in the ANSP (6695). Sturtevant and Wheeler stated that this specimen is a male, but it is clearly a female.

The holotype ♀ of *D. nasalis* is labeled "Long Island[,] Deadman's Cay[,] March 11, 1953/Van Voast-A.M.N.H. Bahama Isls. Exped Coll. E.B.Hayden/♂/♂ HOLOTYPE Diphuia nasalis W.W.Wirth [red, gender and species name handwritten]." The holotype is point mounted, is in good condition (tip of right wing folded back on itself), and is deposited in the AMNH. Although the holotype was listed as a male (Wirth 1956:4) and the specimen is so marked, it is a female.

Other specimens examined.—*BAHAMAS.* Crooked Island, Landrail Point, 5 Mar 1953, E. B. Hayden, L. Giovannoli (1 ♀; AMNH); Exuma Cays, Staniard Bay, 13 Jan 1953, E. B. Hayden (1 ♀; AMNH); Long Island, Deadman's Cay, 11 Mar 1953, E. B. Hayden (2 ♂; AMNH, USNM). *BELIZE.* Stann Creek District: Bread and Butter Cay, 25 Mar 1988, W. N. Mathis (5 ♂, 1 ♀; USNM); Glover's Reef (Long Cay, Middle Cay, Northeast Cay, Southwest Cay), 26–28 Jul 1989, W.N. Mathis (29 ♂, 12 ♀; USNM); Man of War Cay, 8–15 Nov 1987, W. N. & D. Mathis (7 ♂, 4 ♀; USNM); Twin Cays (West Bay), 22 Mar 1988, W. N. Mathis (1 ♂, 1 ♀; USNM); Wee Wee Cay, 24–25 Mar 1988, 21 Jul 1989, W. N. Mathis (5 ♂; USNM). Six Belize, 1959, N. L. H. Krauss (1 ♂; USNM). *BERMUDA.* Hamilton Parish. Shelly Bay, 20 Nov 1987, D. J. Hilburn, N. E. Woodley (2 ♀; USNM). *DOMINICAN REPUBLIC. Barahona:* Cabral (canals E of Cabral; 18°15.2′N, 71°13.4′W), 16 May 1995, W. N. Mathis (1 ♂, 1 ♀; USNM). *La Romana:* Isla Saona, Catuano (18°11.7′N, 68°46.8′W), 13 May 1995, W. N. Mathis (1 ♂; USNM). *GRAND CAYMAN.* Governor Gore Bird Sanctuary (19°16.7′N, 81°18.5′W), 25 Apr 1994, W. N. Mathis (1 ♂; USNM). *JAMAICA.* Falmouth (bay shore), 1 Mar 1969, W. W. Wirth (1 ♂; USNM); Milk River Bath (mangroves), 11 Mar 1970, T. Farr, W. W. Wirth (5 ♂, 1 ♀; USNM); Negril Beach (rocky shore), 12 Mar 1970, W. W. Wirth (1 ♂; USNM); Runaway Bay (bay shore), 16–28 Feb 1969, W. W. Wirth (3 ♂; USNM). *UNITED STATES.* Florida. Monroe Co., Bahia Honda Key (seashore), 11



Figs. 1–8. *Diphuia nitida.* 1, 5th tergum and sternum, lateral view. 2, 5th tergum, dorsal view. 3, Male terminalia (epandrium, cercus, surstyli), lateral view. 4, Gonite, lateral view. 5, Internal male terminalia (gonite, hypandrium, aedeagal apodeme, aedeagus), lateral view. 6, Aedeagus and aedeagal apodeme, lateral view. 7, Hypandrium, aedeagal apodeme, and aedeagus, ventral view. 8, Hypandrium, lateral view. Scale = 0.1 mm.

Apr 1970, W. W. Wirth (4 ♂, 3 ♀; USNM); Big Pine Key, 11-Apr-30 Dec, 1954, 1970, H. V. Weems (1 ♂, 1 ♀; USNM); Long Key, 23 Jun 1953, M. R. Wheeler (1 ♂; UTA); Saddlebunch Keys, 29 Dec 1953, H. V. Weems (1 ♂, 1 ♀; USNM). North Carolina. Onalow Co., Ashe Island, 11 Aug 1975, J. C. Dukes (1 ♀; USNM).

Distribution.—Nearctic: USA (FL, NC, NY). Neotropical: Bahamas, Belize, Bermuda, West Indies (Dominican Republic, Grand Cayman, Jamaica).

Natural history.—The vast majority of specimens from the Belizean cays were collected by sweeping just above mangrove peat that is well shaded most of the day. A few specimens, apparently feeding, were collected on flowers. The association with mangrove peat must be opportunistic, as the species occurs in areas where mangrove does not now exist.

Diagnosis.—This species is distinguished from congeners, especially *D. anomala* and *D. zatwarnickii,* by the sparsely microtomentose mesofrons; the subshiny mesonotum that is very sparsely invested with fine, golden brown microtomentum; the sparsely, whitish gray microtomentose anepisternum; the shiny anterior half of the katepisternum; and several characters of the male terminalia (see description and figures).

Remarks.—Since 1989, when the research from my earlier revision (Mathis 1990) was completed, I have studied longer series of specimens from additional localities. These studies indicate that *D. nasalis* and *D. nitida* are conspecific, with the latter being the senior synonym. Although no more specimens from the type locality (New York: Long Island, Douglaston) of *D. nitida* have become available, I now strongly suspect that the difference noted earlier between the nominate species has mostly to do with the poor condition of the holotype female of *D. nitida.* This specimen, which is the entirety of the type series, appears to have been "rubbed" (antennae and several setae are missing), which could also account for the shinier frons, the only distinguishing character.

Diphuia flinti **Mathis, new species**
(Figs. 9–16)

Description.—Small to moderately small shore flies, length 1.60 to 2.10 mm.

Head: Frons sparsely and uniformly invested with fine brownish to grayish microtomentum. Ventral portion of face with median, vertical, densely microtomentose, silvery white stripe extended dorsad from and connected to microtomentose ventral margin.

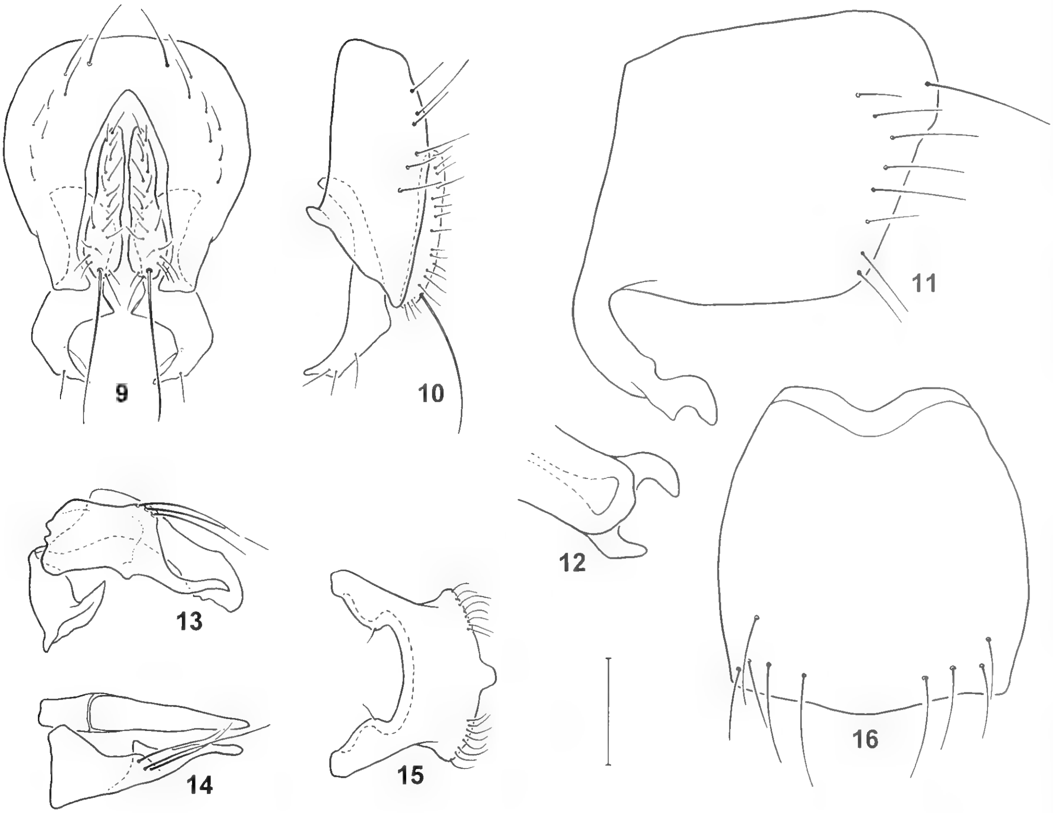
Thorax: Mesonotum, including postpronotum and notopleuron, sparsely invested with fine brownish to golden brown microtomentum, mostly subshiny; anepisternum, anepimeron, and posterior half of katepisternum sparsely invested with fine, whitish gray microtomentum; anterior half of katepisternum with oval spot bare of microtomentum, shiny. Wing with costal vein ratio 0.58; M vein ratio 0.40.

Abdomen: 5th tergum with anterior margin emarginate medially (Fig. 16); 5th sternum a narrow arch that is connected anteriorly with 5th tergum (Fig. 11), apex with 2 flanges (Fig. 12). Male terminalia (Figs. 9–10, 13–15) as follows: epandrium higher than wide in lateral view, ventral margin pointed (Fig. 10); surstylus longer than cercus, obtusely angulate in lateral view, apex truncate and pointed medially and anteriorly (Figs. 9–10); gonite in lateral view with basal half subrectangular, with narrow, sinuous, pointed process apically (Figs. 13–14); aedeagal apodeme in lateral view irregularly triangular (Fig. 13); aedeagus rounded apically in lateral view (Fig. 13), pointed (not bifurcate) in dorsal view (Fig. 14); hypandrium in ventral view wider than long, anterior margin deeply arched with medial margins recurved, posterior margin evenly arched except for a short, median process (Fig. 15).

Type material.—The holotype ♂ is labeled "DOMINICAN REPUB. El Seibo: near Rincón[,] 18°45.3′N, 68°55.7′W[,] 12 May 1995, WNMathis/USNM ENT 00136995 [bar code label]." The allotype ♀ and 14 paratypes (10 ♂, 4 ♀) bear the same locality label as the holotype. Other paratypes are as follows: *DOMINICAN REPUBLIC. El Seibo:* El Seibo (5 km E; 18°44.73′N, 68°59.2′W; 120 m), 12 May 1995, W.N. Mathis (1 ♂, 5 ♀; USNM). The holotype is double mounted (minuten in silicon plastic block), is in excellent condition, and is deposited in the USNM.

Distribution.—Neotropical. Dominican Republic (El Seibo).

Diagnosis.—I can distinguish this species only on the basis of structures of the male terminalia, especially the shape of the 5th



Figs. 9–16. *Diphuia flinti.* 9, Epandrium, cerci, and surstyli, posterior view. 10, Same, lateral view. 11, 5th tergum and sternum, lateral view. 12, Apex of 5th sternum, ventral view. 13, Gonite, aedeagus, and aedeagal apodeme, lateral view. 14, Left gonite and aedeagus, dorsal view. 15, Hypandrium, ventral view. 16, 5th tergum, dorsal view. Scale = 0.1 mm.

tergum, surstylus, gonite, aedeagus, and hypandrium as described and illustrated.

Natural history.—The type series was collected along the banks of the Rio Quisibani, which is a freshwater stream.

Etymology.—It is a pleasure to name this species after Dr. Oliver S. Flint, Jr., who accompanied me on the field work that resulted in the collection of this species.

Phylogenetic Considerations

Diphuia is in the tribe Hecamedini (Mathis 1991a, 1991b, 1993) and belongs to the clade including *Hecamede* Haliday and *Allotrichoma* Becker, *sensu lato,* including *Pseudohecamede* Hendel (Mathis 1991a). This relationship is evidenced by the retracted fifth tergum of the male, which is moderately elongate, almost tubular. *Diphuia* may be the sister group to the rest of the *Allotrichoma* clade, following Cresson's (1944) original assessment, although the evidence supporting this relationship is not compelling, and *Diphuia* could be mostly closely related to *Hecamede* Haliday.

The monophyly of *Diphuia* within Hecamedini is well established (see generic diagnosis for a partial list of synapomorphies), and the remainder of this section will be devoted to the phylogenetic relationships among the species. First the character evidence is presented, followed by a brief discussion that is intended to complement the cladogram.

Character evidence.—The characters used in the cladistic analysis are listed be-

Table 1. Matrix of characters used in the cladistic analysis of *Diphuia.*

Taxa	Characters								
	1	2	3	4	5	6	7	8	9
Outgroug	0	0	0	0	0	0	0	0	0
D. anomala	1	0	1	2	1	1	1	1	1
D. zatwarnickii	1	0	1	2	1	1	1	1	1
D. nitida	0	1	0	0	0	0	0	0	0
D. flinti	0	0	0	1	1	1	1	1	0

low and the distribution of their states is shown in the matrix (Table 1) and discussed here. For each character, the plesiomorphic condition is indicated by a 0, and the relative apomorphic condition(s) is indicated by a 1 or 2.

1. Vestiture of mesonotum: (0) sparsely microtomentose, subshiny; (1) moderately densely microtomentose.
2. Vestiture of anepisternum: (0) sparsely, uniformly microtomentose; (1) anteroventral ½ to ⅓ bare, shiny.
3. Length of 5th tergum of male: (0) longer than wide (Figs. 1–2, 11, 16); (1) wider than long (Figs. 1–2, 16–17 in Mathis 1990).
4. Shape of anterior margin of 5th tergum of male: (0) straight, even; (1) shallowly emarginate; (2) deeply emarginate, V-shaped (Figs. 2, 17 in Mathis 1990).
5. Shape of ventral margin of epandrium: (0) broadly formed, somewhat truncate; (1) tapered to point.
6. Shape of surstylus: (0) rounded; (1) truncate ventrally, pointed.
7. Shape of gonite: (0) trapezoidal with sides more or less equal (Fig. 4); (1) somewhat rectangular, longer than high (Fig. 13).
8. Shape of posterior margin of hypandrium: (0) smooth and even; (1) with a small, median projection.
9. Shape of aedeagus: (0) slender, 3–4× longer than high in lateral view; (1) more robust, length in lateral view about twice height (Figs. 7, 21 in Mathis 1990).

Discussion.—Analysis of the character evidence (Table 2), all morphological and primarily from the male terminalia, resulted in a single cladogram (Fig. 17). The single tree resulted from the implicit enumeration (ie*) option of Hennig86 and has a length of 10 steps and consistency and retention indices of 1.00 and 1.00, respectively. The analysis of characters is given in Table 2.

The cladogram (Fig. 17) for the four species consists of three bifurcations, with *D. nitida* at the base and the remaining species as the sister group. The monophyly of the latter assemblage is established by characters four (1) and five through eight. The next bifurcation has *D. flinti,* which is known thus far only from the Dominican Republic, branching off and as the sister group to *D. anomala* and *D. zatwarnickii.* The monophyly of the *D. anomala* and *D. zatwarnickii* group is indicated by four characters (1, 3, 4(2), 9).

ACKNOWLEDGMENTS

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Funding for this research project, es-

Table 2. Analysis of characters used in the cladistic analysis.

Character:	1	2	3	4	5	6	7	8	9
Steps:	1	1	2	1	1	1	1	1	1
Consistency Index:	100	100	100	100	100	100	100	100	100
Retention Index:	100	100	100	100	100	100	100	100	100

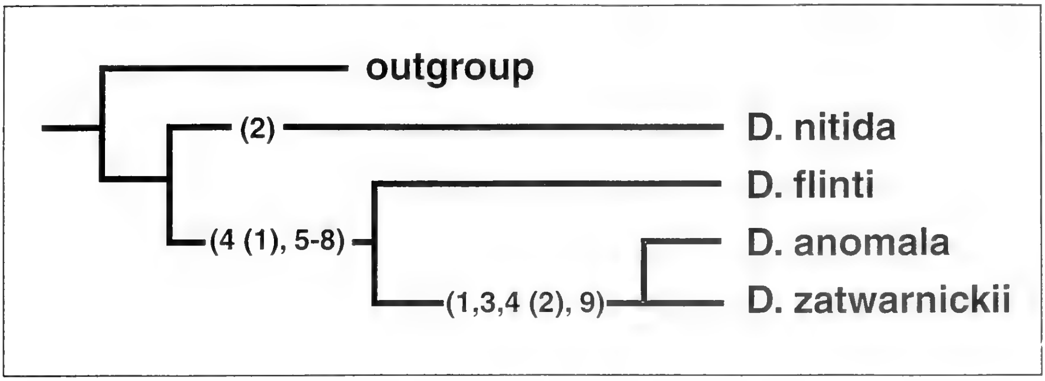

Fig. 17. Cladogram depicting hypothetical relationships among species of *Diphuia*. Tree length 10 steps, consistency index 1.00, retention index 1.00.

pecially the field work in Belize and the Dominican Republic, was provided by the Caribbean Coral Reef Ecosystems (CCRE) and Biodiversity Program (Biological Surveys and Inventories, BSI), National Museum of Natural History, Smithsonian Institution. This is contribution number 501 of the CCRE project, which is partially supported by a grant from the Exxon Corporation.

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99(1), 1997, pp. 37–41

A NEW SPECIES OF *DRYMUS* FIEBER FROM MEXICO, WITH A KEY TO SPECIES AND A CHECKLIST OF WESTERN HEMISPHERE DRYMINI (HEMIPTERA: LYGAEIDAE)

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Abstract.—The first Mexican species of *Drymus* Fieber, is described as ***Drymus mexicanus***, n. sp., from the mountains of the state of Veracruz. A key to the Western Hemisphere species is included together with a list of the Western Hemisphere species of the tribe Drymini. A discussion of the distribution of the tribe is given and the affinities of the Nearctic fauna analyzed.

Key Words: *Drymus*, Mexico, biogeography, distribution, checklist

The zoogeography of the Rhyparochrominae was reviewed in detail by Slater (1986). In that paper he noted the interesting distribution of the members of the tribe Drymini and how closely the overall distribution paralleled that of the tribe Rhyparochromini. Both of these tribes are abundant, diverse and speciose in the Palearctic, Ethiopian-Oriental (= Paleotropical) and Australian regions. However, both make up only a very small proportion of the Nearctic rhyparochromine fauna and both are absent from the the true Neotropical Region (including the West Indies). Of the Nearctic fauna most species belong to genera that are also found in the Palearctic.

The Drymini tend to be associated with woodland margins and to live in moderately mesic habitats. The Rhyparochromini occur for the most part in relatively dry savannah-like habitats.

The absence from the Neotropics of Drymini, despite their abundance in Africa, suggests a radiation subsequent to 90 million years b.p. or subsequent to the breakup of West Gondwanaland. It also suggests that despite the abundance of the Drymini in Australia they are relatively recent elements in that fauna since there was apparently no movement of such a fauna across Antarctica (and because there are no native species in New Zealand). The most plausible scenario for the occurrence of Drymini in the Western Hemisphere appears to be as a Holarctic element that was present during, or before, the onset of the Pleistocene. If this is true, it means that two taxa have been able to reach generic status during this period (both of which are confined to areas of California that escaped glaciation).

The Mexican drymine fauna is found in montane areas and all species are members of genera also found in the United States and Canada as well as in the Palearctic. *Drymus* is the most unusual of these in that the two previously known species are known from only a few localities in the western United States.

All measurements are in millimeters.

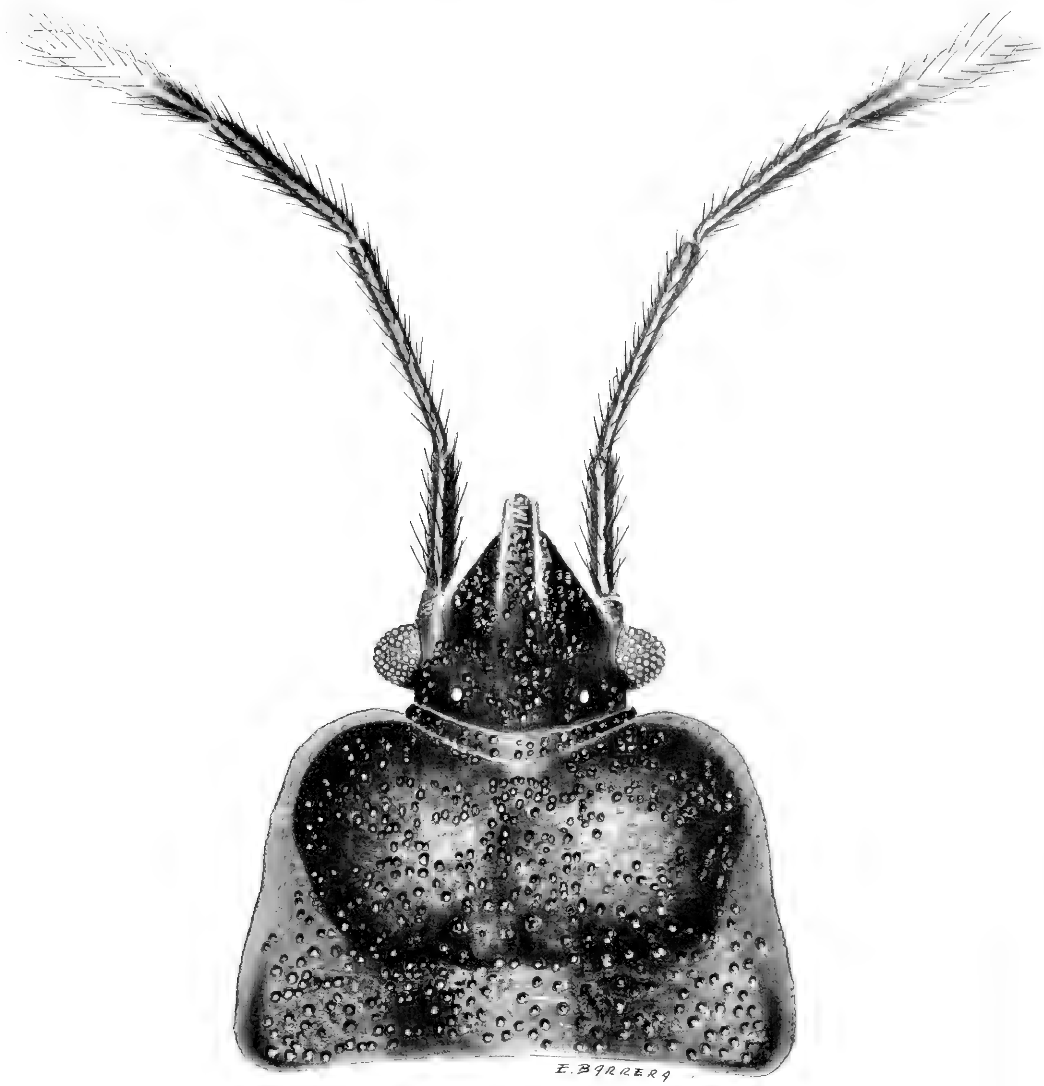

Fig. 1. *Drymus mexicanus*. Dorsal view, head and pronotum.

Drymus mexicanus, Slater and Brailovsky, new species

(Figs. 1, 2)

Robust, subelliptical. Head, anterior pronotal lobe, scutellum and antennae dark chocolate brown, almost black. Explanate pronotal margins, posterior pronotal lobe, entire hemelytron, legs and labium dull reddish-brown. Fourth antennal segment with apical two-thirds white. Coarsely punctate over entire surface except wing membrane, the punctures on head and anterior pronotal lobe relatively small.

Head acuminate, non-declivent; tylus attaining distal one third of first antennal segment; vertex convex. Eyes set well away from anterior margin of pronotum. Length head 0.84, width 1.00, interocular space 0.82. Pronotal calli confluent or nearly so, mesally, elevated above surface of posterior lobe. Lateral pronotal margins broadly explanate (Fig. 1); posterior margin of pronotum shallowly concave. Length prono-

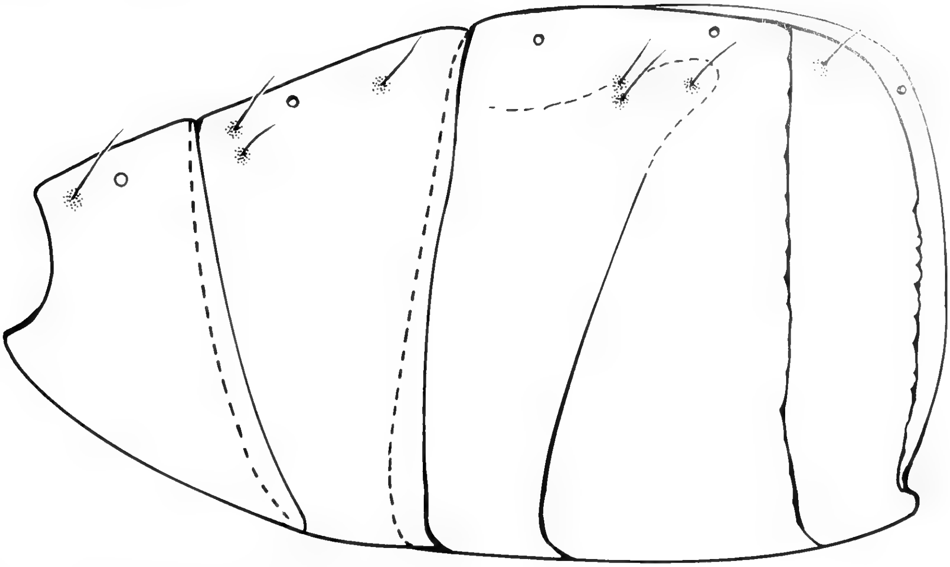

Fig. 2. *Drymus mexicanus.* Abdomen, lateral view.

tum 1.20, width 2.00. Scutellum with a median elevation distally, mesally concave on basal half. Length scutellum 1.12, width 1.20. Hemelytra with lateral margins broadly convex. Clavus with four rows of punctures. Length claval commissure 0.60. Midline distance apex clavus-apex corium 1.24. Midline distance apex corium-apex membrane 0.64. Metathoracic scent gland auricle curved posteriorly. Evaporative area only slightly exceeding end of auricle, distally truncate, covering only mesal one-third to one-fourth of metapleuron. Fore femur only moderately incrassate, armed below on distal one fourth with a short sharp spine with three minute spines distad. Labium extending to metacoxae, first segment not attaining base of head. Length labial segments I 0.62, II 0.70, III 0.54, IV 0.44 (approx.). Length antennal segments I 0.50, II 0.80, III 0.62, IV 0.68. Total body length 5.65.

All abdominal spiracles located below sternal shelf. Posterior pair of trichobothria on sternum four located dorsoventrally, the ventral trichobothrium reduced and obsolete (Fig. 2).

Holotype ♀ MEXICO: *Veracruz*: Naolinco, 1.VIII.1977, 2100 m. In Universidad Nacional Autonoma de Mexico collection.

This is a very distinctive species at once separable from the other Western Hemisphere species by the white distal portion of the fourth antennal segment, the much more strongly explanate lateral pronotal margins, and the shorter antennae. Actually this is not the only species of *Drymus* with a pale distal end to the fourth antennal segment; several Palearctic species have a somewhat paler apex on segment four, although none that we have examined have a white terminal end to the antennae.

KEY TO WESTERN HEMISPHERE SPECIES OF *DRYMUS*

1. Distal half of fourth antennal segment white, strongly contrasting with dark coloration of basal half of antennae; explanate margins of pronotum broad, subequal to width of second antennal segment; second antennal segment subequal in length to length of head . . . . *mexicanus* n. sp.
– Fourth antennal segment unicolorous dark brown to black; explanate lateral pronotal margins relatively narrow, much narrower than width of second antennal segment; second an-

tennal segment considerably longer than length of head 2

2. Large (6.5–7 mm); very dark almost black; anterior and posterior pronotal lobes nearly evenly punctate; expanded lateral margins of pronotum concolorous with doraal surface of pronotum . . . . *crassus* Van Duzee

– Smaller (rarely over 5 mm); dull brown; anterior pronotal lobe more finely punctate than posterior lobe; expanded lateral margins of pronotum usually slightly paler than surface of pronotum . . . . *unus* (Say)

CHECKLIST OF WESTERN HEMISPHERE DRYMINI

See Slater 1964 and Slater and O'Donnell 1995 for complete references.

Drymus Fieber

crassus Van Duzee 1910. New England south to Florida, west to Texas and South Dakota.
mexicanus, n. sp. Mexico.
unus (Say) 1831. Eastern Canada, south to North Carolina, west to Colorado.

Eremocoris Fieber

arnaudi Brailovsky 1982. Mexico.
borealis (Dallas) 1852. Western U.S.A.
canadensis Walley 1929. British Columbia; Idaho.
chalmaensis Brailovsky and Barrera 1981. Mexico.
cupressicola Ashlock 1979. California.
depressus Barber 1928. New England south to Florida and Louisiana coastal areas.
dimidiatus Van Duzee 1921. Colorado.
extremus Brailovsky and Cervantes 1989. Mexico.
ferus (Say) 1832. Widespread over much of U.S.A. and southern Canada.
garciai Brailovsky and Barrera 1981. Mexico.
guerrerensis Brailovsky and Barrera 1981. Mexico.
inquilinus Van Duzee 1914. California.
legionarius Brailovsky and Barrera 1981. Mexico.
lopezformenti Brailovsky and Barrera 1981. Mexico.
melanotus Walley 1929. British Columbia; Idaho.
mimbresianus Brailovsky and Cervantes 1989. Mexico.
obscurus Van Duzee 1906. California; Idaho; British Columbia.
opacus Van Duzee 1921. California.
semicinctus Van Duzee 1921. California; Idaho.
setosus Blatchley 1926. Eastern U.S.A.
squalidus Brailovsky and Barrera 1981. Mexico.

Gastrodes Westwood

arizonensis Usinger 1938. Arizona.
conicolus Usinger 1933. California.
intermedius Usinger 1938. British Columbia.
pacificus (Provancher) 1886. Nebraska and Colorado, west to Calfornia and British Columbia.
walleyi Usinger 1938. Ontario, British Columbia.

Scolopostethus Fieber

atlanticus Horvath 1893. Northern U.S.A. and southern Canada; Newfoundland to British Columbia south to New Jersey and New Mexico.
diffidens Horvath 1893. Northern U.S.A. and southern Canada: Nova Scotia to British Columbia south to New Jersey.
pacificus Barber 1918. California, Idaho, British Columbia.
thomsoni Reuter 1874. Almost throughout Holarctic.
tropicus (Distant) 1882. California to Guatemala.

Thylochromus Barber

nitidulus Barber 1928. California.

Togodolentus Barber

wrighti (Van Duzee) 1914. California.

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NESTING BEHAVIOR OF *KROMBEINICTUS NORDENAE* LECLERCQ, A SPHECID WASP WITH VEGETARIAN LARVAE (HYMENOPTERA: SPHECIDAE: CRABRONINAE)

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Abstract.—Nesting behavior of the recently described Sri Lankan wasp, *Krombeinictus nordenae* Leclercq, is discussed. Females nest in the hollow internodes of the leguminous myrmecophyte, *Humboldtia laurifolia* Vahl. The biology of this stem-nesting crabronine is unique among Sphecidae in several aspects. An adult female exhibits remarkable maternal care, rearing one larva at a time, and feeding it progressively. Progressive provisioning has not been noted previously for any Crabroninae. Nests lack cell partitions and mature larvae are transported to the basal regions of their stems for cocoon spinning. The cocoon is also unlike that of any other known crabronine species, exhibiting adaptations to internode morphology and allowing movement of adults within the nest cavity. Finally, *K. nordenae* is remarkably different from all other known Sphecidae in feeding pollen rather than paralyzed arthropod prey to its larvae.

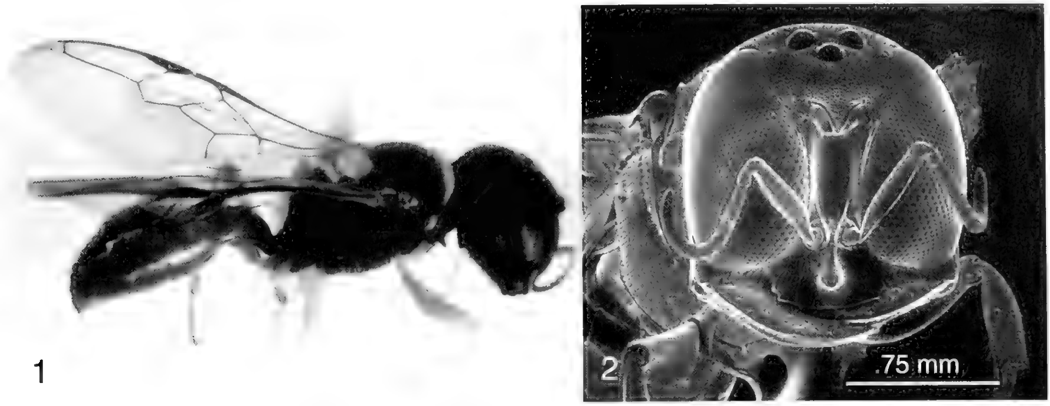
Key Words: Sphecidae, Crabroninae, *Humboldtia*, Sri Lanka, internode, myrmecophyte, cocoon, pollen

Sri Lanka has been called the land of serendipity. A recent example is the amazing nesting behavior of a Ceylonese wasp, a newly described genus and species, *Krombeinictus nordenae* Leclercq (1996). This pretty little wasp (Fig. 1), 5–6 mm long, has creamy to pale yellow markings on its black head and thorax, and a mostly light red abdomen bearing narrow, transverse, brown to black stripes on some of the dorsal segments. *Krombeinictus* belongs to the Sphecidae, normally a family of predaceous, mostly solitary wasps.

MATERIALS AND METHODS

Our first encounter with this species was when we received a single male of *K. nordenae* from a colleague, Prof. Fred R. Rickson. It was among a few wasps that emerged from a dozen internodes of the myrmecophyte, *Humboldtia laurifolia* Vahl, that he collected in the Sinharaja Forest Reserve in Sri Lanka in 1992.

We visited Sri Lanka in 1993, and spent five days (18–20 Jul and 2–3 Aug) in the rainforest near Gilimale, Ratnapura District, 06°46′N, 80°26′E. We hoped to make behavioral observations on *Krombeinictus* during this brief period, but intermittent rains of the delayed monsoon season precluded nesting activity by the wasps. However, we censused about a thousand internodes from *H. laurifolia*, and placed several hundred unopened stems directly into alcohol for subsequent study. These internodes were split open carefully in the laboratory to avoid damaging associated organisms, and notes were made on their contents.



Figs. 1–2. *Krombeinictus nordenae*, female. 1, Lateral view. 2, Frontal view of head.

Humboldtia laurifolia Vahl
(Figs. 3–6, 12–15)

This botanical section is condensed from a detailed account of the plant's morphology in Krombein et al. (in prep.). *Humboldtia laurifolia* (Fabaceae) (Fig. 3) occurs only in Sri Lanka; three other species of the genus and one variety occur in southern India. *Humboldtia laurifolia* is a small understory tree, growing to a height of about 10 m, found in the lowland rainforest of the southwestern quadrant of Sri Lanka. It usually grows along streams or in seeps, is highly gregarious, and occurs in groups of ten to several hundred trees.

Humboldtia laurifolia and two of its Indian congeners, *H. brunonis* Wallich and *H. decurrens* Beddome ex Oliver, are of particular interest to naturalists because they are myrmecophytes that have coevolved with several species of ants. The trees provide swollen internodes, each with a self-opening entrance, that serve as domatia for the ants. The trees also provide an abundance of extrafloral nectaries on leaves, stipules and inflorescences whose secretions are attractive to the ants. In turn, the ants protect the foliage, especially the tender, young leaves, from herbivory.

Humboldtia laurifolia is typical of legumes in having pinnately compound leaves, each leaf having four to six pairs of opposite leaflets (Fig. 4). As in many legumes there is a developmental period during which a flush of four or five new internodes, each with an associated leaf, is produced over a period of two months. As the internode develops, the apical part becomes inflated, and is filled with pith. When the internode matures, the pith collapses against the inner wall, forming a hollow cavity, and a slit-like opening develops near the apex (Fig. 5). The opening widens gradually until ants or other small organisms can access the hollow domatium. Some occupants apparently gnaw at the more or less elliptical opening, transforming it to an oval or circular opening that is gradually rimmed by a callus (Fig. 6), the plant's response to the injury. Aculeate Hymenoptera (ants, wasps, bees) remove the pith to make the cavity larger, except for one species of solitary crabronine wasp, *Crossocerus mukalanae* Leclercq which uses the pith in constructing its nest in the cavity.

We found aculeates nesting in internodes ranging in length from 4.3 to 11.2 cm. The basal end of the internode is woody to a variable extent, so the length of the cavity varies from 3.2–6.3 cm. The woody outer wall of the internode is 0.3–0.7 mm thick. The internode entrances are elliptical to circular in shape with width to length measurements ranging from a minimum of 1.1 × 1.1 mm to a maximum of 1.2 × 1.8 mm.

Figs. 3–6. *Humboldtia laurifolia*. 3, Habitat; collecting on plant. 4, Leaf; note swollen internode at lower right. 5, Internode opening early in development. 6, Internode opening to *Krombeinictus nordenae* nest; note callus around hole.

Krombeinictus nordenae Leclercq
(Figs. 1, 2, 7–11)

Apparently an uncommon wasp, we found only eight specimens (6 ♀, 2 ♂) in *Humboldtia* internodes at Gilimale as compared to several hundred of its fellow crabronine, *Crossocerus mukalanae*. It has unusual morphology in that it is the only genus of Crabroninae, other than the Oriental *Vechtia* Pate, in which both sexes possess a triangular lamella overhanging the deep scapal basin (Fig. 2).

The female is unusual morphologically in the Crabroninae in lacking a pygidium delimited by carinae on the last abdominal tergum. Instead there is a median brush of several rows of close-set, erect setae (Fig. 7). The last abdominal segment of females usually bears the residue of a secretion from abdominal glands (Fig. 8) that we believe may function as an ant guard. We suspect that a nesting female uses its brush of setae to smear this secretion around the nest entrance to deter predators and parasites from entering while the adult wasp is foraging.

The Oriental *Piyumoides* Leclercq, considered by him (1996) to be the genus most closely related to *Krombeinictus*, also lacks a pygidium. Females, however, lack the median brush of setae on the last abdominal tergum. There is no secretion from abdominal glands on this segment in females of three of the four known species in our collection.

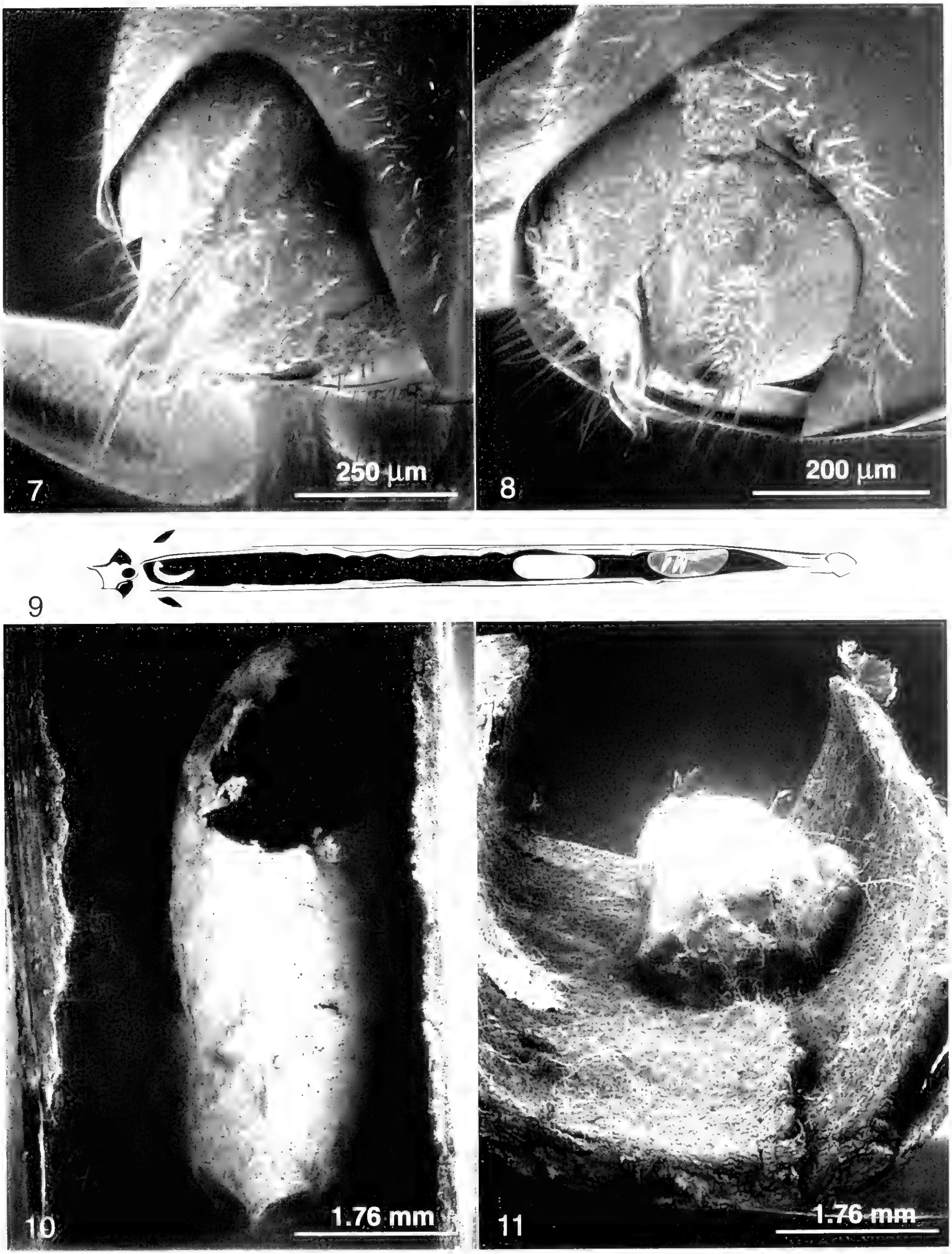
Nest.—We found only ten nests of *K. nordenae* compared with about 75 of *C. mukalanae*, and adult females were present in only four of them. We believe that the missing females took flight during the period between gathering *Humboldtia* branches, and placing the internodes in alcohol. Several females were found sheltering in empty internodes.

One typical nest exhibited the sequence of nesting activity (Fig. 9). The internode was 6.3 cm long, and the maximum width was 4.0 mm. The interior cavity was 5.0 cm long and had a maximum width of 3.4 mm. When we split the internode, we found a small wasp larva, 2 mm long, on the wall of the cavity just below the entrance hole. The female was lower in the cavity, probably a reaction to being immersed in alcohol when the internode was preserved. There was a wasp pupa with well developed adult coloration in its cocoon at the bottom of the cavity. Ten mm above this cocoon was a second cocoon that contained a postdefecated larva just prior to pupation.

From these data, and observations in other internodes with nesting *K. nordenae*, we deduce the following behavioral sequence. The foundress lays the first egg on the inner cavity wall just below the entrance. When the larva hatches, she feeds it progressively until mature. The wasp then transports it to the bottom of the cavity where it subsequently spins its cocoon, pupates, and slowly begins to develop adult coloration. After the wasp takes the mature larva below, she lays a second egg just below the entrance. That larva is fed progressively, and, when mature, it is transported lower in the cavity for cocoon spinning. The same cycle is repeated again with the wasp depositing another egg below the entrance.

Typically, many sphecid wasps that nest in pithy stems or borings in wood construct nests containing a linear series of cells. The cells are sealed by partitions that separate siblings, thus preventing cannibalism. Further, nests are normally closed before eggs hatch so that females have no contact with their progeny. Thus, the progressive feeding, maternal attention, and lack of partitions is noteworthy in *K. nordenae*.

Cocoon.—The cocoon also is unique among the Crabroninae. The typical crabronine cocoon is more or less ovoid, circular in cross section, the posterior end tapers rather narrowly, and there is a pore at the anterior end, as in *Ectemnius paucimaculatus* (Packard) (Krombein, 1964). The cocoon of *Krombeinictus* (Fig. 10) is broadly ovoid, tapers very slightly posterad, and lacks a pore at the anterior end. The upper surface is only slightly convex so that in



Figs. 7–11. *Krombeinictus nordenae*. 7, Female, apex of abdomen lateral oblique; note median brush of setae on last tergum. 8, Female, apex of abdomen, lateral oblique from rear; note dried secretion on last segment, and on fifth sternum. 9, Nest diagram. 10, Cocoon in section of internode from which adult emerged. 11, Cocoon in section of internode, oblique; note ample space for passage of adults.

cross section the cocoon is more curved on the side that is appressed against the rounded inner wall of the internode. Cocoon dimensions are 6–9 mm long, 2.6–3.4 mm wide, and 2.0–2.1 mm high.

There is a space at least 2 mm high between its upper surface and the opposite inner wall of the cavity (Fig. 11). A cocoon of this shape permits the mother to crawl over a cocoon to carry a mature larva toward the lower end of the cavity, or for a newly emerged adult from lower in the internode to crawl over a higher cocoon to reach the nest entrance.

Larva.—The data above support our conclusion that the female feeds her larva progressively. We found larvae in various stages of development, but never with any prey or inedible prey fragments such as wings and legs that one would expect to find in the nest of a predaceous wasp. The problem of larval food identity was finally solved when we examined the exuviae of post-defecated larvae, and adjacent fecal wastes. Unmistakably, small grains of pollen had been excreted with the meconium (Fig. 12) which were identical in size and appearance with grains of *Humboldtia* pollen (Fig. 13). Also, we noted that freshly preserved larvae had a distinct yellow color reminiscent of that seen in bee larvae that have fed on pollen. Variations in larval bee color are attributed to pollen color (Norden, 1984).

Later in our investigation, Rickson sent us a female of *K. nordenae* that he collected from an internode in Gilimale. We found clumps of *Humboldtia* pollen grains on the mandibles and hypostomal setae beneath the head (Figs. 14, 15). Due to the oily pollenkitt that envelops the pollen grains, they tend to adhere to each other and to insects that come in contact with the stamens.

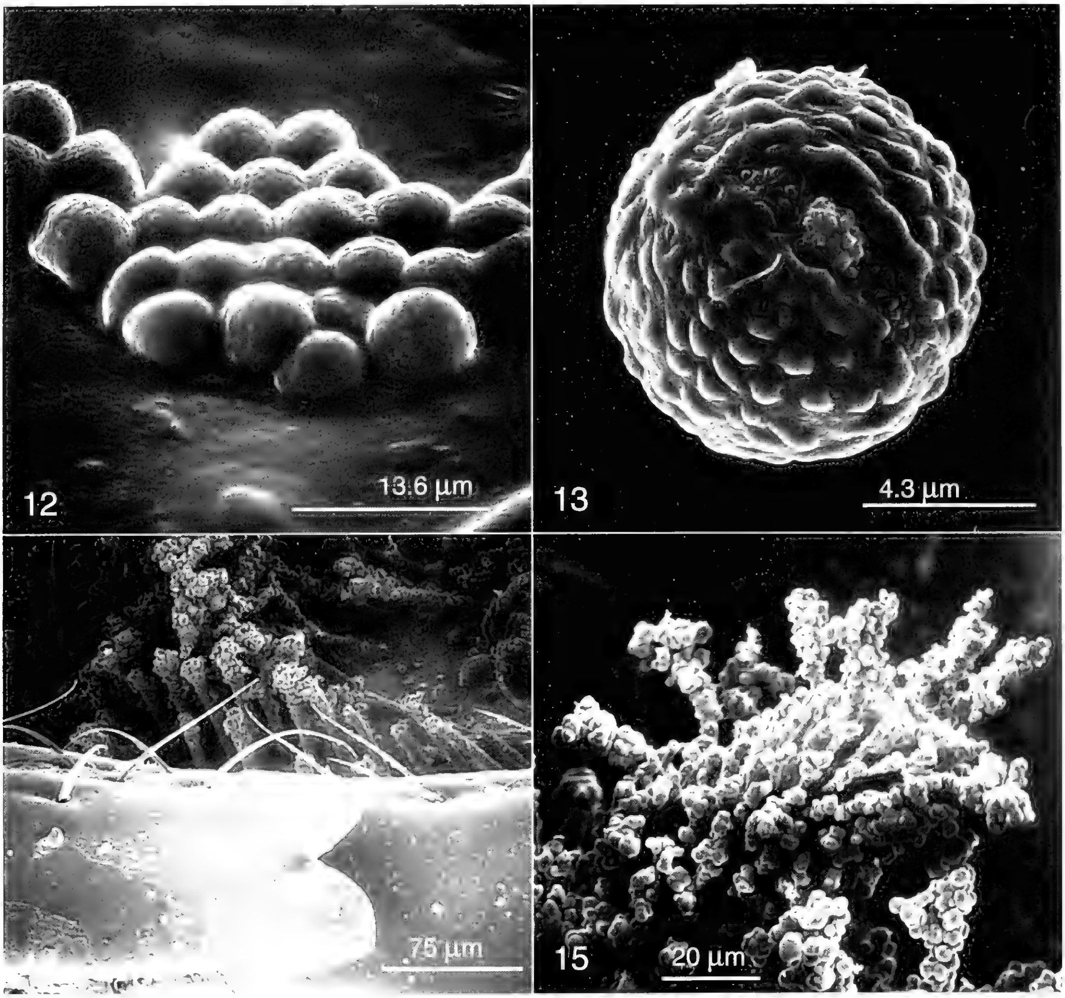
We infer from these data that the female probably gathers a quantity of the clumped *Humboldtia* pollen on the hypostomal area, returns to the internode, and deposits the pollen on the inner wall next to the head of the larva. Again, this feeding behavior is remarkable and in contrast to all known sphecids whose larval food consists of paralyzed arthropods.

DISCUSSION

Behaviorally, *K. nordenae* is unusual or unique among Sphecidae in several characteristics of its life history. The female manifests extraordinary maternal care, rearing one larva at a time, and feeding it progressively. Progressive provisioning has not been noted previously for any Crabroninae. Evans (1966) reported that it developed independently at least four times in the Nyssoninae. Evans also noted that eggs are produced more slowly in progressive provisioners than in mass provisioners. However, the slow development that characterized our nests may actually be related to scarcity of pollen and thus a slower rate of feeding rather than to the rate of egg production. *Humboldtia* flowering occurs throughout the year, but the major production of inflorescences is usually February to June.

The foundress with several brood in varying stages of development forms a subsocial group. Additional field observations are needed to ascertain whether this subsocial group reaches the level of social behavior by having a daughter join the foundress in caring for later brood.

There is also the possibility that *K. nordenae* is so coadapted to *Humboldtia* that the wasp nests only in the plant's internodes, where nearby there is a plenitude of extrafloral nectaries for adult feeding, and pollen when the plant is in bloom. It is noteworthy that the wasp was never collected during the dozen years of the Smithsonian's "Ceylon Insect Project," 1968–1980. None of the project specialists collected on *Humboldtia*, but several of us, including the first author on a number of trips, collected at emergence holes in dead wood, and in tunnels in wood, and failed to find *K. nordenae* in these other plants. If *K. nordenae* is in fact associated only with *Humboldtia*, we wonder if it or other species of *Krombeinictus* may have a similar relation-



Figs. 12–15. *Humboldtia laurifolia* pollen. 12, Pollen mass in meconium within cocoon of *Krombeinictus nordenae*. 13, Grain from flower bud. 14, Pollen grains clumped on hypostomal setae behind mandibular apex of female *K. nordenae*. 15, Pollen grains massed on setae beneath head of female *K. nordenae*.

ship in southern India with *H. decurrens* and *H. brunonis*.

The cocoon also is unlike that of any other known crabronine. Clearly it is an adaptation to the morphology of the internode cavity and nesting behavior of the foundress which permits movement of adults throughout the cavity. The cocoon of the normal twig-nesting crabronine is slightly less in diameter than that of the cavity. The larva spins a loose network of silken guy-lines against the entire wall of the cavity and then constructs the cocoon, suspending it within the network (Krombein, 1964, fig 7b, shows cocoons not in contact with cell wall). The cocoon of *K. nordenae* is spun directly in contact with the rounded inner wall of the internode, and there are only a few silken guy-lines along the cocoon margins.

Finally, and perhaps most significant, the species is extraordinarily different from all other known Sphecidae in feeding its larvae pollen rather than paralyzed arthropod prey.

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We are grateful to our late colleague and friend, P.B. Karunaratne, for his many years of help to scientists conducting field studies in Sri Lanka. The Smithsonian Institution's "Ceylon Insect Project" (1968–1980) was highly successful in large part because of Karu's dedication and knowledge. During our trip in 1993 he introduced the authors to *Humboldtia* habitat, and helped collect many of the internodes we examined. We dedicate this work to him.

We also thank Arnold W. Norden who was with us during part of our 1993 visit, provided valuable support in field studies, and reviewed an earlier draft of the manuscript.

We gratefully acknowledge Prof. Fred R. Rickson, Department of Botany and Plant Pathology, Oregon State University, Corvallis, for bringing *H. laurifolia* to our attention, explaining the morphology and phenology of the myrmecophyte, and for insect specimens from his collecting in Sri Lanka during 1992.

We are further indebted to Prof. Jean Leclercq, Liége, Belgium, for describing *Krombeinictus nordenae*. It is an honor to have our names bestowed on this bizarre wasp with such unusual behavior.

Within the Smithsonian we thank Susann G. Braden who prepared most of the scanning electron micrographs, and George L. Venable who prepared the stem drawing and photographic plates.

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FENDEROMYIA SHAW, A VALID NORTH AMERICAN TAXON IN MACROCERINAE (DIPTERA: MYCETOPHILOIDEA: KEROPLATIDAE)

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Abstract.—The North American genus *Fenderomyia* Shaw, 1948, was long believed to be a junior synonym of *Macrocera* Meigen, based on an artifact in thorax pleura and several plesiomorphic states of characters. Identification of a specimen of the type species, *F. smithi* Shaw, shows that the thoracic structure described by Shaw was not an artifact, and makes it possible to point out several peculiar morphological characters of the taxon. A phylogenetic analysis shows that these characters are autapomorphic and justifies the resurrection of *Fenderomyia*. The genus is also present in the Neotropical Region.

Key Words: Macrocerinae, *Fenderomyia*, valid generic status, morphology, character analysis

The genus *Fenderomyia* was erected by Shaw (1948) for a new North American species, *F. smithi*, allied to *Macrocera* Meigen, but which differed from this genus by the following characters: base of median vein distinct and reaching to the "m-cu" crossvein, costa produced far beyond apex of wing, and mesepimeron not reaching the metapleuron.

Coher (1963) rightly pointed out that the venation characters cited by Shaw for his new genus occured also in several species of *Macrocera*. He added that Shaw's interpretation of the pleural sclerites was erroneous, based on "a variable condition shown by a series of *M. brunnea* Brunetti, 1912, to be a result of distortion during drying rather than of actual structure". Accordingly, Coher considered *Fenderomyia* a junior synonym of *Macrocera*.

Laffoon (1965) recognized *Fenderomyia* as a valid genus, but it is doubtful that he knew of Coher's paper before the completion of his manuscript for the North American Catalog, which includes only "some 1963 names". Thompson (1975), discussing the pleural morphology of *Lygistorrhina*, mentions the synonymy established by Coher, and Vockeroth (1981) does not include *Fenderomyia* in his key to the genera of Nearctic Mycetophilidae, which means that he also accepts Coher' synonymy.

Matile (1990), revising the generic classification of Macrocerinae, discussed the status of *Fenderomyia* and generally agreed with Coher, noted that all three venation characters were plesiomorphic for the group, and accepted the thoracic distortion explanation.

In some unsorted material of Macrocerinae at the National Museum of Natural History, Smithsonian Institution (USNM), I identified a specimen belonging to Shaw's species. It was collected in Oregon (Coos Co., Charleston, VI. 1963, NLH. Krauss), as was Shaw's type-series. As a result of an examination of this specimen and comparison with the extensive collection of Keroplatidae available to me, it is now possible to resurrect *Fenderomyia* from synonymy on the basis of several morphological characters.

It is significant that the attribution to an artifact of an exceptional feature, the abridged mesepimeron, and the obviously plesiomorphic venation characters cited by Shaw for his new genus, have diverted the attention of all subsequent authors, the present one included, from the other very significant characters cited in the original description.

MATERIAL AND METHODS

The USNM specimen is a male (according to habitus) in rather poor condition: The antennae, most of the legs, and the tip of abdomen are broken (only the first five segments are present). It was originally glued laterally to a piece of cardboard. The integument of the thorax was slightly transparent, thus showing the thoracic muscles; the chitin of the pleura was smooth, without trace of infolding or outfolding, and the mesepimeron was definitely shortened. The specimen was detached from the cardboard and gently heated in distilled water, which demonstrated that the ventral margin of the mesepimeron corresponded to a true suture, with an internal phragma. One of Shaw's diagnostic characters of *Fenderomyia* was thus confirmed. The head was further boiled in KOH to check the absence of a membranous area between cerebral phragma and front or occiput, thus confirming its position in the Macrocerini rather than the Robsonomyiini. The specimen was then dried by the method of Sabrosky (1966), modified by the replacement of cellosolve by monoethylene glycol (Matile 1994), and then glued back to its cardboard. The head was preserved in glycerine in a microvial.

According to the original description, the type series of *F. smithi* should be in Shaw's collection, presently at the University of Massachussetts. Dr. T.M. Peters was unable to locate it either under *Macrocera* or *Fenderomyia*. Dr. R. J. Gagné was kind enough to make inquiries about the possible location of these specimens, but without success, and writes "we will just have to assume that the types were never distributed to the intended institutions and are probably lost" (in litt. Apr. 1996).

CHARACTER ANALYSIS

Four characters, presumably apomorphic, can be added to the character of the shortened mesepimeron of *Fenderomyia*: the long stem of the anterior fork; the diagonal strip of dense, erect black setae of the metepisternite, briefly mentioned in the original description, which runs under the posterior spiracle and above the dorsal margin of the pleurite; the angular, short mediotergite, strongly projecting backwards behind the scutellum; and the presence of only one spur on all tibiae. I have examined these five features on about 100 species of *Macrocera*, described or undescribed, from all biogeographical regions, as well as in an extensive collection of other Keroplatidae and related families. The five characters are discussed below.

1. Mesepimeron.—The evolution of the mesepimeron has been discussed in Matile (1990: 378, 411), and outgroup comparison has shown that the most primitive condition in most Nematocera was a vertical plate reaching the lower margin of the pleura at the level of the metepisternite. In the Mycetophiloidea, the plate narrows ventrally, and the disappearance of its ventral part is undoubtedly apomorphic. The phenomenon has occured several times in the Keroplatidae—at least twice in the Macrocerinae, e.g. in *Vockerothia* Matile (Macrocerini) and *Micrepimera* Matile and an undescribed genus in Robsonomyiini—and once in the Keroplatinae, namely in *Nauarchia* Matile (Keroplatini). It is also a trait of all Lygistorrhinidae and most Ditomyiidae.

2. Stem of anterior fork.—As regards the stem of the media in the studied species of *Macrocera*, the anterior fork always opens far basad of the base of R_5, except in two Neotropical species, *M. guayanasi* Lane and *M. unidens* Edwards. Among the other Macrocerinae, a long stem as in *Fendero-*

myia is present only in a group of Australasian *Paramacrocera* Edwards, and in the Oriental genus *Micrepimera* Matile. In my character analysis of the anterior fork of the Mycetophiloidea (Matile 1990: 438), I noted that fossil evidence was in favor of the plesiomorphy of a long petiole, and inferred that its shortness in the Keroplatidae was apomorphic, and part of their groundplan. The condition of *Fenderomyia*, *Micrepimera*, the two South American *Macrocera* and the Australasian *Paramacrocera* should thus be a reversal, and its appearance in at least four groups of Macrocerinae the result of parallelism.

3. Postspiracular setae.—There is often in Keroplatidae a sparse patch of short setae at the posterior or ventral margin of the metepisternite, but the dorsal rows of dense setae in *F. smithi* do not really stand on the metepisternite, but above it, on the perispiracular membrane, a few of the ventral setae extending to the extreme dorsal margin of the sclerite (Figs 1a, b). These setae should in fact properly be named infraspiracular setae. I have been unable to find this feature in any Macrocerinae, in Arachnocampinae and Keroplatinae (Keroplatini). I have checked also representatives of almost all the described genera of Orfeliini and have found this character absent also. It does not exist in the more primitive family Ditomyiidae, nor in the presumed sister-group of the Keroplatidae, the Diadocidiidae (for a provisional phylogenetic analysis of the relationships of the families of Mycetophiloidea, see Matile 1990: 383—386). The apomorphic state of the character seems therefore well founded.

4. Mediotergite.—In most *Macrocera* known to me, the mediotergite is high, subvertical in its upper half, then curves gently downward and forward to meet the metanotum, thus not projecting behind the scutellum, or very slightly so. In a few species, the sclerite is evenly rounded and projects somewhat behind the scutellum, the condition illustrated by Shaw for *M. formosa* Loew, but never in such proportions as in *Fenderomyia* (Fig. 1a; compare also Shaw's Figs. 1 and 2).

The evolution of the mediotergite has been studied (Matile 1990: 405), and out-group comparison has shown that its primitive condition in Mycetophiloidea was a vertical, high and slightly rounded sclerite. In fact, this character is one of the nine used to separate Macrocerini and Robsonomyiini, the two tribes of Macrocerinae. Within the subfamily, the projecting mediotergite was considered autapomorphic for the Robsonomyiini. The condition of *Fenderomyia* thus must have appeared independently once in Macrocerini.

5. Tibial spurs.—Only one tibia and three tarsomeres, as well as some isolated tarsomeres, remained on the piece of cardboard of the USNM specimen and these became detached as the glue dissolved; the absence of a sensorial crypt indicates that the remaining tibia belongs to leg II or III; it has only one very short spur. Shaw states "tibia with one spur", and he had three specimens available, therefore I assume that his observation refers also to both the median and posterior legs.

The loss of the outer spurs II–III is an evolutionary trend of the Keroplatidae (Matile 1990: 418) which occured independently once in the Keroplatinae Keroplatini (*Xenokeroplatus* Matile), and several times in the Orfeliini, but the state of this character was not known up to now in the Macrocerinae, although the reduction in size is common. Most *Macrocera* known to me have two posterior spurs, the longest about twice as long as the width of the tibia at its apex. Occasionally, the spurs are reduced to one tibial width, or a little less. Only in *M. guayanasi* and *M. unidens* are there two very minute spurs as observed on the Argentinian *Fenderomyia* mentioned below.

DISCUSSION

The validity of *Fenderomyia* is supported by five strong apomorphies. The short median fork is shared by two species of *Macrocera* (both with a rather shortened medi-

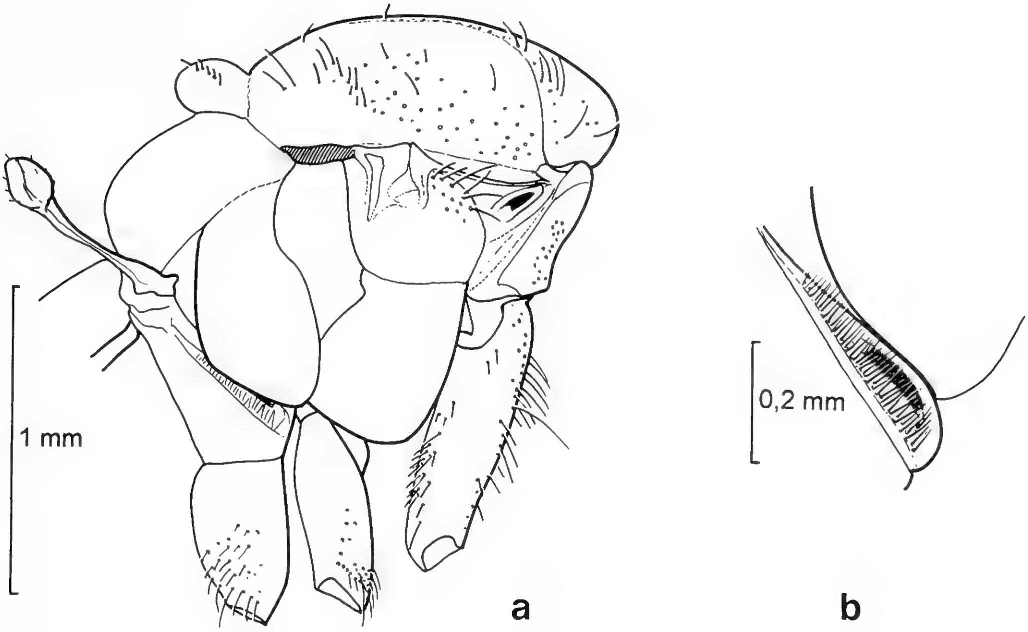

Fig. 1. *Fenderomyia smithi* (USNM specimen). a, Lateral view of thorax and coxae. b, Posterior spiracle and infraspiracular setae.

otergite), and does not exist elsewhere in the subfamily. The thoracic structure has appeared several times in the subfamily, but never in *Macrocera*. The projecting, shortened mediotergite is unique for the Macrocerini, while it is characteristic of the Robsonomyiini. The loss of the external tibial spurs II–III is not yet known to happen in the Macrocerinae. Lastly, the infraspiracular rows of setae are unique in the family Keroplatidae and its closest relatives. This amply justifies the acceptance of *Fenderomyia* as a valid taxon, if only to emphasise this peculiar set of apomorphies.

In the Duret Collection of Neotropical Mycetophiloidea, now preserved in the Muséum national d'Histoire naturelle, Paris, I found an unidentified female of "*Macrocera*" (Argentina, Salta, Campo Quijuano) which shares with *F. smithi* the disappearance of the ventral part of the mesepimeron, the long stem of the median fork and the projecting mediotergite, but lacks the dorsal row of infraspiracular setae. Sc_2 is definitely absent, but the basal fold of the media is very faint. The two anterior legs and one posterior leg are left; there is a short spur on tibia I, and two very minute spurs on the III, smaller than the basal diameter of the protarsus. I am reluctant to describe formally the species from a unique female, but the specimen certainly represents the closest known relative of *F. smithi*. Therefore, the infraspiracular setae would be autapomorphic for *F. smithi*.

Provisionally, pending a revision of *Macrocera*, I propose to follow Shaw and to recognize *Fenderomyia* as a valid genus close to *Macrocera*, with the following diagnosis:

Fenderomyia Shaw, 1948: 94. Type species: *Fenderomyia smithi* Shaw, 1948: 94 (original designation).

A genus close to *Macrocera*, sharing with this genus the globular antennal scape and the long flagellum, but differing in the incomplete mesepimeron, interrupted at the level of lower third of the laterotergite, the projecting mediotergite, the stem of the medial fork long, ending at level of the base of R_5. In the type species, posterior spiracle with several rows of posterior setae and only one tibial spur II–III. In the Neotropical species, spiracular setae absent, and hind tibia with two minute spurs.

Additional characters of taxonomic or phylogenetic significance in *Macrocera* or Macrocerini are: Cerebral sclerite large, meeting the eyes at their anterior corner, bearing long anterior setae. Thorax and coxae as in Fig. 1a, acrostichal bristles absent. Scutellum with short, fine marginal bristles. Mesanepisternite with long, erect, dorsal setae. Subscutellar membranous area narrow. Wing: C strongly produced after R_5, Sc_2 visible as a trace (USNM specimen) or absent, basal fold of the media very strong (*F. smithi*) or faint (Neotropical species). Anal vein long, reaching to the margin. Wing membrane without macrotrichiae. Ciliation of veins, dorsal surface: C, R_5, branches of the anterior fork, M_4, Cu_{1b} and tip of anal vein. Male genitalia simple, of the *Macrocera* type (Shaw, 1948: fig. 4).

Distribution: Nearctic and Neotropical.

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My thanks are due to Dr. Raymond J. Gagné for the loan of an important material of Keroplatidae from USNM, including the specimen discussed above, and for his search for the type series of *Fenderomyia smithi*. Drs. R. J. Gagné and D. Williams were kind enough to revise the language of the manuscript. I thank also Gilbert Hodebert for the drawings.

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CLADISTICS AND BIOGEOGRAPHY OF THE ASSASSIN BUG GENUS *MELANOLESTES* STÅL (HETEROPTERA: REDUVIIDAE)

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Abstract.—*Melanolestes* Stål is a monophyletic genus of nine species, two Nearctic and seven Neotropical. A cladistic analysis of the genus was carried out using 28 characters. The cladograms were rooted with the genus *Peirates* Serville. The analysis yielded 20 equally parsimonious cladograms, with 34 steps, CI = 0.52, and RI = 0.44. A successive weighting procedure resulted in one cladogram with 77 steps, CI = 0.84, and RI = 0.87. The distribution of *Melanolestes* coincides in part with a previous study on Peiratinae, that showed that the former continuous Amazonian forest was separated into two parts by a diagonal line of open areas. In addition, the two Nearctic species *M. picicornis* and *M. picipes* are sister-taxa, so a single dispersal event accounts for the presence of *Melanolestes* in the Nearctic.

Key Words: Peiratinae, Reduviidae, cladistics, biogeography

The New World assassin bug genus *Melanolestes* Stål (Heteroptera: Reduviidae: Peiratinae) is known from southeastern Canada to northern Argentina. The nine species belonging to this genus have been recently revised (Coscarón and Carpintero 1994). Two of these species, *M. picicornis* Stål and *M. picipes* (Herrich-Schaeffer), are restricted to the Nearctic Region, whereas the remainder are Neotropical. Within the Neotropics, *M. goiasensis* Coscarón and Carpintero, *M. lugens* Coscarón and Carpintero, *M. minutus* Coscarón and Carpintero, and *M. picinus* Stål have very small distributional areas within the Amazonian and Chacoan domains. In a previous biogeographic study (Morrone and Coscarón 1996), we analyzed distributional patterns of the Neotropical Peiratinae, concluding that these patterns have been basically caused by the gradual development of a diagonal line of open areas (Chaco-Cerrado-Caatinga), which separated the former continuous tropical forest into two parts.

In this paper we provide a cladistic analysis of *Melanolestes*, and discuss its biogeographic patterns.

MATERIAL AND METHODS

This study is based on the revision of *Melanolestes* by Coscarón and Carpintero (1994), and the examination of specimens borrowed from the following collections: American Museum of Natural History, New York, USA; The Natural History Museum, London, United Kingdom; Instituto Nacional de Pesquisas Amazonicas, Manaus, Brazil; Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires, Argentina; Museo de La Plata, La Plata, Argentina; Museu de Zoologia de Sâo Paulo, Sâo Paulo, Brazil; Naturhistoriska Riksmuseet, Stockholm, Sweden; Zoologisches Museum der Humboldt Universität zu Ber-

Table 1. Data matrix and characters of the species of *Melanolestes* used in the analysis. 0 = plesiomorphic character states; 1, 2 = apomorphic character states; ? = missing data.

Peirates	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
M. argentinus	0 0 1 0 0 1 1 0 0 0 0 1 0 0 1 1 1 1 1 1 0 0 0 0 1 0 1 1
M. degener	0 2 1 0 0 1 1 0 0 0 0 1 ? 0 1 1 1 1 1 1 1 0 0 ? ? ? 1 ?
M. goiasensis	0 2 1 1 0 1 1 0 1 0 0 1 ? 1 1 1 1 1 1 1 1 0 0 ? ? ? 1 ?
M. lugens	0 2 1 0 1 1 0 1 2 1 0 1 1 0 1 1 0 1 0 0 0 0 0 0 1 1 1 0
M. minutus	0 2 1 0 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 0 0 ? ? ? 1 ?
M. morio	0 2 1 0 0 1 1 0 1 0 0 1 0 ? 1 1 1 1 1 1 0 0 0 0 1 0 1 0
M. picicornis	0 0 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0 0 1 1 0
M. picinus	1 1 0 0 0 1 0 0 1 0 0 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
M. picipes	0 2 1 0 0 1 1 1 1 1 0 1 0 0 1 1 1 1 1 1 0 0 0 0 1 0 1 1

1. Body shape. [0] slender; [1] robust.
2. Eyes. [0] not attaining superior edge of head; [1] attaining superior edge of head; [2] surpassing superior edge of head. Treated as additive.
3. Ocelli. [0] not placed on a tubercle; [1] placed on a tubercle.
4. Lateral tubercle on neck. [0] present; [1] absent.
5. Metallic shine in pronotum. [0] absent; [1] present.
6. Pronotal granulations on anterior lobe. [0] absent; [1] present.
7. Pronotal granulations on posterior lobe. [0] absent; [1] present.
8. Pronotal sulci. [0] distinct; [1] not distinct.
9. Pronotal lateral internal sulci. [0] distally united; [1] medially united; [2] not united. Treated as non-additive.
10. Lateral margin of pronotum. [0] carina absent; [1] carina present at entire length.
11. Scutellum coloration. [0] unicolorous; [1] bicolored.
12. Spongy fossa. [0] not occupying distal third of fore and hind tibiae; [1] occupying distal third of fore and hind tibiae.
13. Female hemelytra. [0] macropterous; [1] brachypterous.
14. Hemelytra. [0] surpassing apex of abdomen; [1] not surpassing apex of abdomen.
15. Body color, [0] not uniform; [1] uniform.
16. Hemelytral pale stripe on corium and clavus. [0] present; [1] absent.
17. Color of fore femora. [0] bicolored; [1] unicolorous.
18. Color of hind femora. [0] unicolorous; [1] bicolored.
19. Color of fore tibiae. [0] unicolorous; [1] bicolored.
20. Color of mid tibiae. [0] unicolorous; [1] bicolored.
21. Connexivum. [0] dorsally visible; [1] dorsally not visible.
22. Connexivum color. [0] unicolorous; [1] bicolored.
23. Parameres shape. [0] subrectangular; [1] subtriangular.
24. Gonocoxite IX internal edge hairs. [0] thin; [1] thin and thick.
25. Gonocoxite IX unsclerotized area close to inner margin. [0] absent; [1] present.
26. Shape of IX and X tergites. [0] subquadrangular; [1] subrounded.
27. Intersegmental line of tergites IX and X. [0] not entire; [1] entire.
28. Intersegmental line. [0] not strongly sclerotized; [1] strongly sclerotized.

lin, Berlin, Germany; Zoological Museum, University of Helsinki, Helsinki, Finland; and the private collections of D. Carpintero, Argentina; L. Jirón, Costa Rica; and the late J. Maldonado-Capriles, Puerto Rico.

Melanolestes constitutes a monophyletic group that is distinguished from other Peiratinae by the spongy fossa occupying distal third of fore and hind tibiae, body of uniformly dark color, ocelli placed on a tubercle, pronotal granulations on anterior lobe, hemelytra lacking a pale stripe on the corium and clavus, hind femora unicolorous, and intersegmental line of tergites IX and X entire.

The nine species currently assigned to the genus are considered as terminal taxa: *M. argentinus* Berg, *M. degener* (Walker), *M. goiasensis* Coscarón and Carpintero, *M. lugens* Coscarón and Carpintero, *M. minutus* Coscarón and Carpintero, *M. morio* (Er-

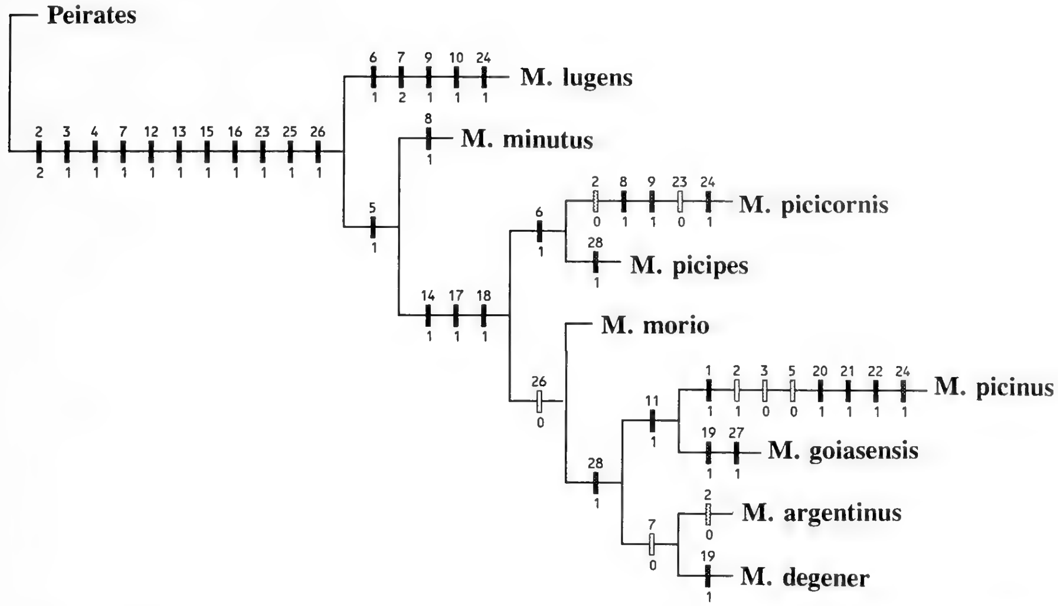

Fig. 1. Cladogram of the species of *Melanolestes*. Synapomorphies = solid black rectangles; homoplasies = dotted rectangles.

ichson), *M. picicornis* (Stål), *M. picinus* Stål, and *M. picipes* (Herrich-Schaeffer).

The data matrix and the 28 characters used in this study are detailed in Table 1. The data were analyzed with Hennig86 version 1.5 (Farris 1988), applying the implicit enumeration (ie*) option for calculating the shortest trees. Consistency (CI) and retention (RI) indices were calculated excluding uninformative characters (autapomorphies and synapomorphies of the genus). We used the successive weighting procedure in Hennig86, that calculates weights from the best fits of the characters on the most parsimonious cladograms using rescaled consistencies (products of the character consistency and the character retention index). These products are scaled in the range 0–10, and the weighting procedure is repeated successively until the cladograms no longer change (Farris 1989). CLADOS version 1.1 (Nixon 1992) was used for examination of character distributions.

RESULTS AND DISCUSSION

The analysis using equal weights yielded 20 equally parsimonious cladograms, each with 34 steps, CI = 0.52, and RI = 0.44. When the successive weighting procedure was applied, one minimum-length cladogram was selected from the original ones after the second round of weighting, with 77 steps, CI = 0.84, and RI = 0.87 (Fig. 1). Values for the number of steps, consistency index (ci), retention index (ri), and weight (ri × ci × 100) in the weighted trees are listed in Table 2. The phylogenetic sequence from the basal to the most distal species is as follows: *M. lugens*, *M. minutus*, *M. picicornis* plus *M. picipes*, *M. morio*, *M. picinus* plus *M. goiasensis*, and *M. argentinus* plus *M. degener*.

Several conclusions can be deduced by comparing the cladogram obtained with the areas inhabited by the species of *Melanolestes* (Fig. 2):

(1) the more basal species (M. lugens) is restricted to the Paranaense province of the Amazonian domain;

(2) *M. minutus* is restricted to the Chacoan domain;

(3) the more widespread species *M. morio* and *M. argentinus* are among the most distal species of the cladogram;

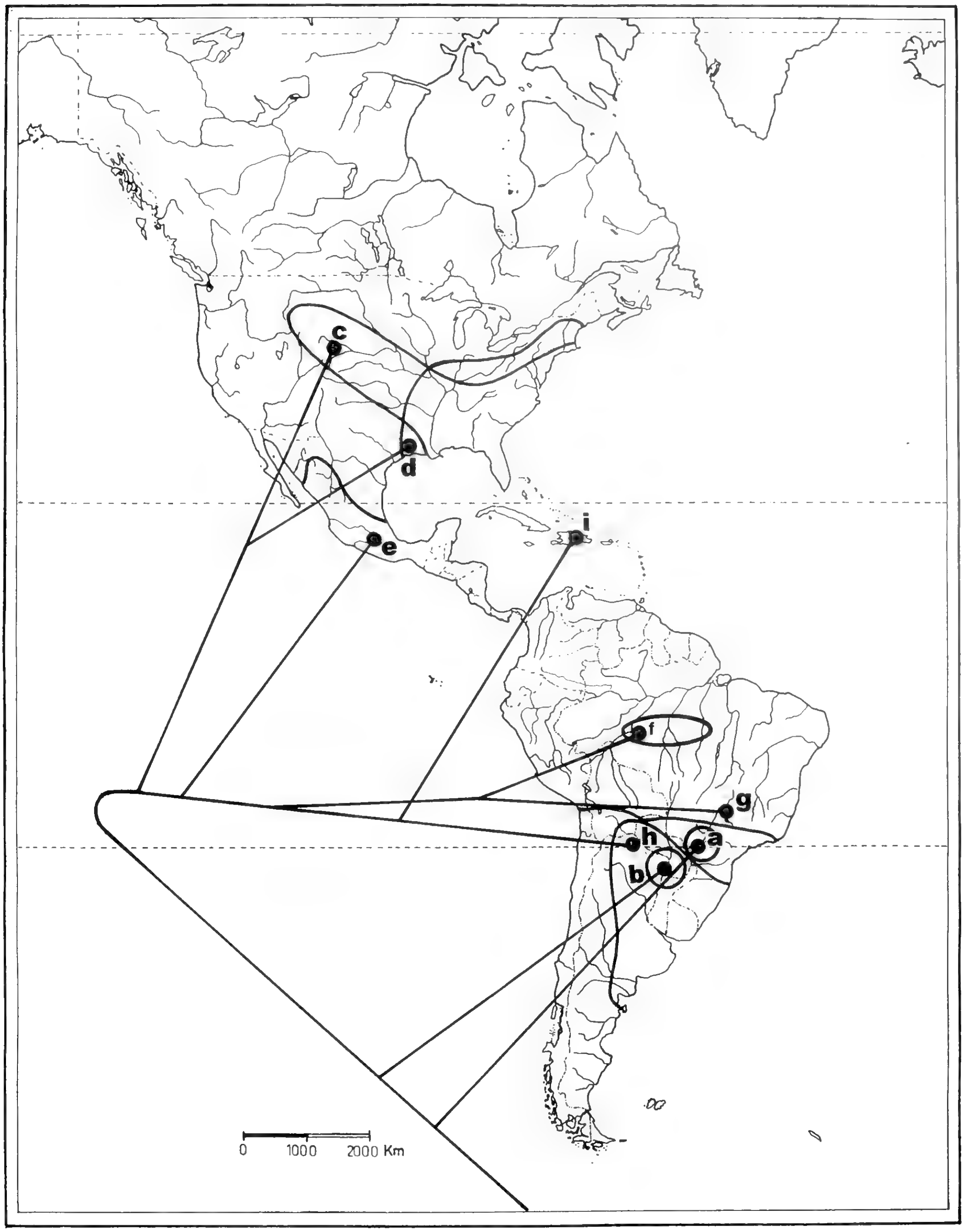

Fig. 2. Geographical distribution of the species of *Melanolestes*, with the cladogram superimposed. a, *M. lugens*; b, *M. minutus*; c, *M. picicornis*; d, *M. picipes*; e, *M. morio*; f, *M. picinus*; g, *M. goiasensis*; h, *M. argentinus*; i, *M. degener*.

Table 2. Character consistencies and retention indices are the best fits of the 20 most parsimonious cladograms obtained applying ie. Final weights were obtained after the second round of the successive weighting procedure.

Character	Number of Steps	Consistency Index (ci)	Retention Index (ri)	Weight (ri × ci × 100)	Final Weight
1	1	1.0	1.0	100	100
2	4	0.5	0.6	30	0
3	1	1.0	1.0	100	0
4	1	1.0	1.0	100	100
5	2	0.5	0.5	25	25
6	2	0.5	0.5	25	25
7	2	1.0	1.0	100	0
8	2	0.5	0	0	0
9	2	0.5	0	0	0
10	1	1.0	1.0	100	100
11	1	1.0	1.0	100	100
12	1	1.0	1.0	100	100
13	1	1.0	1.0	100	100
14	1	1.0	1.0	100	100
15	1	1.0	1.0	100	100
16	1	1.0	1.0	100	100
17	1	1.0	1.0	100	100
18	1	1.0	1.0	100	100
19	1	1.0	1.0	100	100
20	1	1.0	1.0	100	100
21	1	1.0	1.0	100	100
22	1	1.0	1.0	100	100
23	2	0.5	0	0	0
24	2	0.5	0.5	25	0
25	1	1.0	1.0	100	100
26	1	1.0	1.0	100	33
27	1	1.0	1.0	100	100
28	2	0.5	0.5	25	25

(4) the two Nearctic species (*M. picicornis* and *M. picipes*) are sister-taxa.

These results corroborate, in part, our previous study (Morrone and Coscarón 1996), because the Chacoan species *M. minutus* is one of the most basal species, whereas the Amazonian species are among the most distal species. Because *M. picicornis* and *M. picipes* are sister-taxa, a single dispersal event accounts for the presence of *Melanolestes* in the Nearctic.

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AULACIDAE (HYMENOPTERA) OF SRI LANKA

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Abstract.—Three species of Aulacidae from Sri Lanka are keyed, described, and illustrated: *Pristaulacus flavipennis* (Cameron), *P. signatus* (Shuckard), and ***P. krombeini*, n. sp.** Lectotypes for *Aulacus flavipennis* Cameron and *Aulacus magnificus* Schletterer are designated.

Key Words: Aulacidae, *Pristaulacus*, Sri Lanka, parasitoids

Three species of the family Aulacidae are known from Sri Lanka, all of which were among collections of the Smithsonian Ceylonese Insect Project of the 1970's. Two are species previously described from Sri Lanka, and one was undescribed. All are in the genus *Pristaulacus* Kieffer. About 20 species of Aulacidae have been described from the Oriental Region, and six of them are from northern India, but the species from Sri Lanka are distinct.

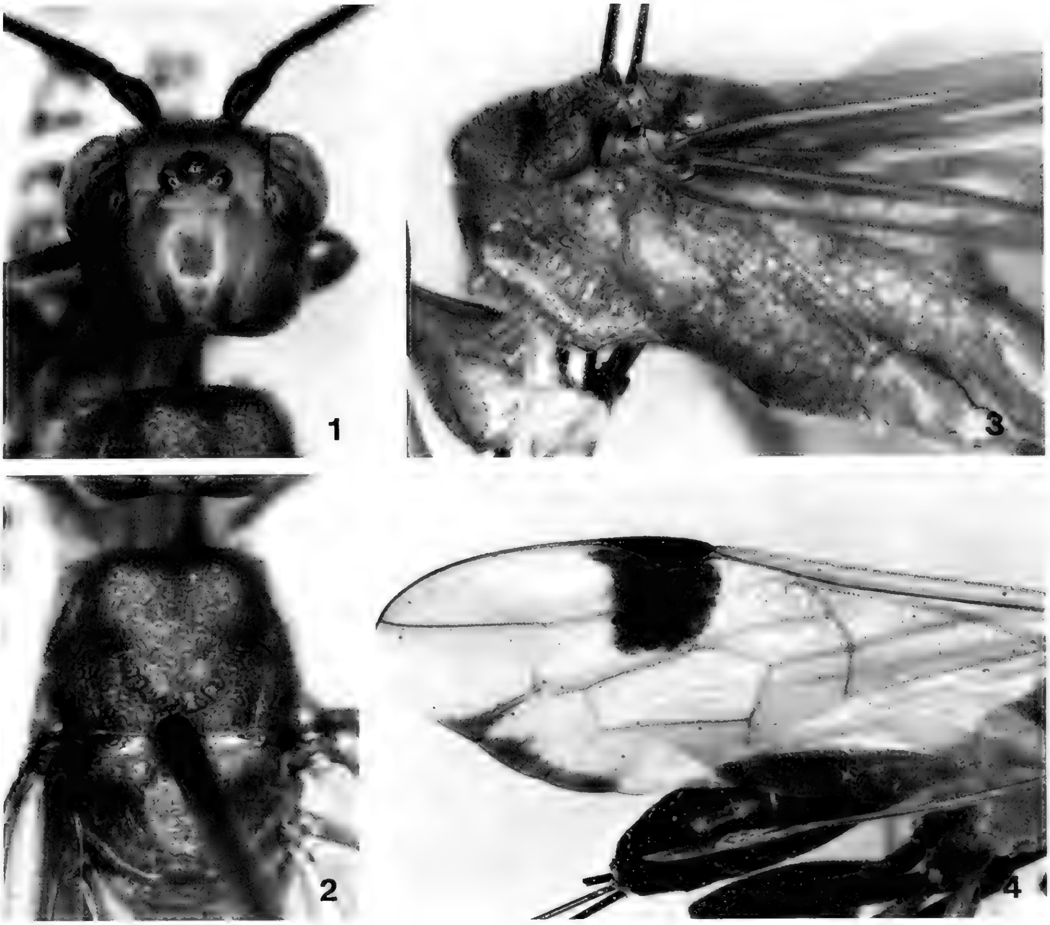
Species of Aulacidae are parasitoids of wood-boring Coleoptera (especially Cerambycidae and Buprestidae) and Hymenoptera (Xiphydriidae). Hosts are not known for the Sri Lankan species, and there are only two host records from southeastern Asia. *Pristaulacus beesoni* Turner, described from "Thano, Siwalik Hills, United Provinces, India" was "taken emerging from a Sal log" (Turner 1922), and a form described as *Pristaulacus nigripes* var. *duporti* Kieffer from Viet Nam was "Obtenu en abondance des larves de *Xylotrechus quadripes* [Cerambycidae]" (Kieffer 1921).

KEY TO AULACIDAE OF SRI LANKA

1. Head, mesosoma, and legs mostly yellow; wings yellowish, forewing sometimes with spot below stigma and apical margin black (Fig. 4), or entirely blackish apical to stigma; mesonotum reticulate (Fig. 2); head in dorsal view elongate behind eyes (Fig. 1) . . . . *P. flavipennis* (Cameron)
– Head and body nearly all black, at most with only antennal scape and pedicel and fore- and midlegs reddish; forewing hyaline except for black substigmatal spot and black spot at apex or with anterior half black; mesonotum with transverse ridges (Figs. 6, 10); head in dorsal view short and narrowing behind eyes (Figs. 5, 9) 2
2. Forewing hyaline with infuscated spot below stigma (Fig. 8); antennal scape and pedicel and fore- and midlegs reddish; mesosoma with rather dense silvery hairs obscuring sculpture (Fig. 7); anterolateral lobes of mesonotum projecting forward in dorsal and lateral views (Figs. 6, 7) . . . .*P. signatus* (Shuckard)
– Forewing infuscated on anterior half, posterior part nearly hyaline (Fig. 12); head, body, and legs black, at most with mandible, tegula, and first metasomal segment reddish to brownish; mesosoma with relatively sparse hairs which do not obscure sculpture (Fig. 11); anterolateral lobes of mesonotum scarcely projecting forward in dorsal view (Fig. 10), projecting upward in lateral view (Fig. 11) . . . . *P. krombeini*, new species

Pristaulacus flavipennis (Cameron)
(Figs. 1–4)

Aulacus flavipennis Cameron 1887: 134



Figs. 1–4. *Pristaulacus flavipennis*. 1, Head, dorsal. 2, Mesosoma, dorsal. 3, Mesosoma, lateral. 4, Wings. 1–3, Specimen from Kegalla District. 4, Lectotype of *P. magnificus*.

(♂).—Kieffer 1912: 371, 372 (in key, ♂ redescribed).

Pristaulacus flavipennis: Turner 1919: 386 (syn.: *magnificus* Schletterer).—Hedicke 1939: 8.

Aulacus magnificus Schletterer 1890: 495, 509, t. 22, f. 131 (♀, ♂).

Pristaulacus magnificus: Kieffer 1900: 338.—Kieffer 1902: 13.—Kieffer 1912: 380, 388 (in key; ♂ and ♀ redescribed).

Female.—Length excluding ovipositor, 16–17 mm; forewing length, 14 mm; ovipositor length, 16–17 mm. Antenna black. Head yellow; apex of mandible black. Mesosoma yellow. Legs yellow with hindleg black except base and inner surface of coxa (lectotype of *magnificus*) or first segment of trochanter, apical third of outer surface of tibia, and tarsus black (specimen from Kegalla District). Metasoma, except base and dorsal surface of first segment black (lectotype of *magnificus*) or orange with apical third of metasomal terga 2–6 blackish (specimen from Kegalla District); sheath black. Wings yellow; forewing with stigma black and large spot below stigma and apicoventral margin black (lectotype of *magnificus*; Fig. 4) or yellow with basal portion of stigma blackish and very faint darker spot below stigma (specimen from Kegalla District). Head from above elongated behind eyes (Fig. 1), shining and impunctate;

occipital carina very short. Propleuron shining and impunctate. Front margin of pronotum with a forward projecting triangular tooth just above its midlength; mesonotum with reticulate sculpture; front margin of mesonotum rounded, slightly lobate, not overhanging pronotum in lateral view (mesosoma as in Figs. 2, 3). Hindcoxa with distinct, coarse cross wrinkles laterally and posteriorly. Tarsal claws with 5 teeth (including apical tooth) and small basal lobe. Ovipositor length about 1.2× forewing length.

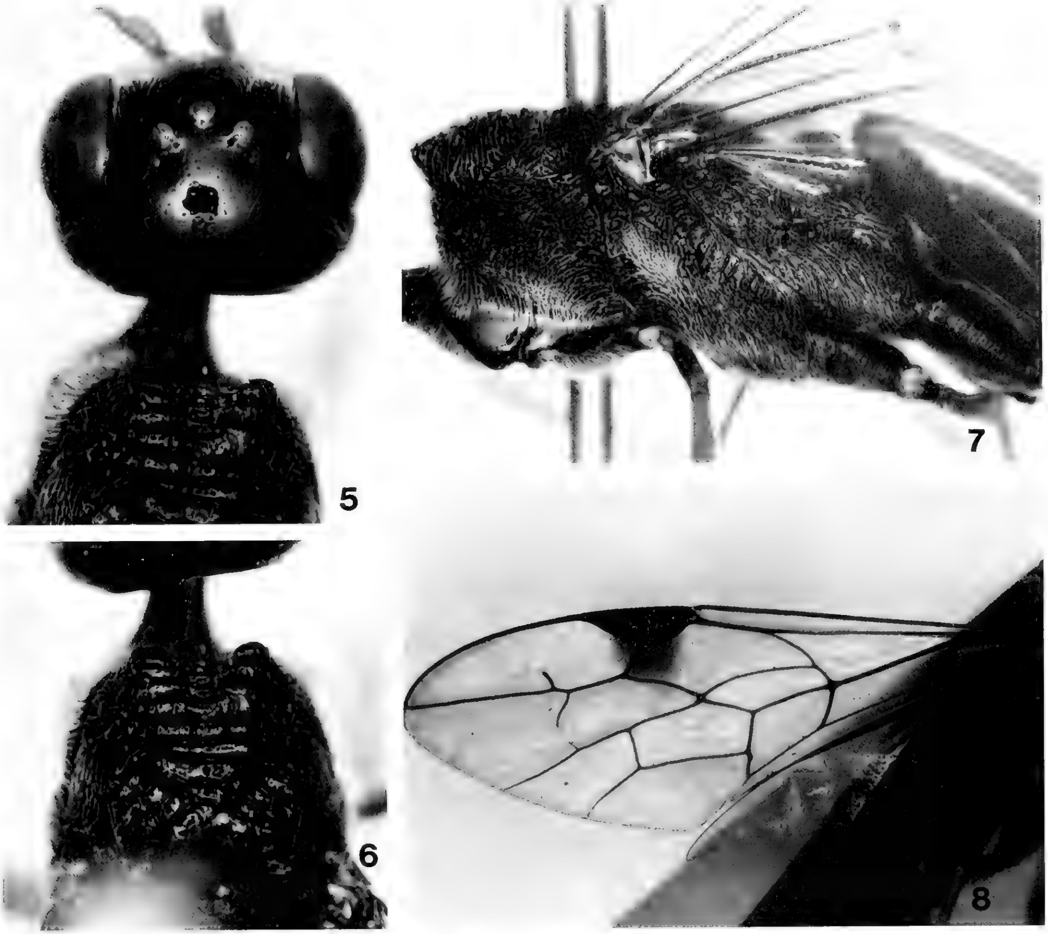
Male.—Length, 15 mm. Color similar to lectotype female (*magnificus*), except smaller substigmatal spot of forewing, which is about half width of stigma and does not enter cubital cells (paralectotypes of *flavipennis* and *magnificus*), or with apex of forewing from base of stigma black (lectotype of *flavipennis*). Structure as for female.

Records.—SRI LANKA: *Kandy District*, Dikoya, 06°52′N, 80°30′E (types of *A. flavipennis*, spelled "Dekaya" by Cameron, 1887). *Kegalla District*, Kitulgala, Makande Mukalana, 3-4-11-1979, K.V. Krombein, P.B. Karunaratne, T. Wijesinhe, S. Siriwardane, T. Gunawardane (1 ♀).

Types.—*Aulacus flavipennis* Cameron was described from two males from "Dekaya, Ceylon (Mr. George Lewis)" The specimens are in The Natural History Museum, London. The colors of the two specimens are slightly different, and Cameron called them "two forms of this species." One specimen is labeled "B.M. TYPE HYM 3.a.139", and this is hereby designated lectotype. The specimen lacks antennae, except for the basal three segments of the left antenna, hindlegs, and the metasoma, except for the first segment. The other specimen, the second "form" described by Cameron, lacks a type label and is considered a paralectotype.

Schletterer described *Aulacus magnificus* from a female and a male. He stated "Type im kaiserl. naturhistorischen Hofmuseum zu Wien (♀) und im königl. naturhistorischen Museum zu Berlin (♂)." I have examined both specimens. The lectotype here designated is the female at the Naturhistorisches Museum Wien, Austria, labeled "Felder [spelling ?], Ceylon, 1861," "magnificus det. Schlett.", and a red label "TYPUS." The specimen is in fair condition with the following parts missing: right antenna beyond basal 4 segments, left antenna beyond basal 6 segments, right forewing, right foreleg, and left midleg. The male, a paralectotype, is at the Zoologisches Museum an der Humboldt-Universität zu Berlin, Germany, labeled "Ceylon, Nietner." "11548," "type" [red label], "magnificus Schlett.," and "Zool. Mus. Berlin." It is in good condition.

Discussion.—Even though there are color differences in the wings, metasoma, and hindlegs among the specimen from Kegalla District (female), the two forms of *A. flavipennis* Cameron (males), and the two specimens of *A. magnificus* Schletterer (female and male), I regard these as probable variation or sexual differences and treat them as the same species. The structure, especially sculpture, of all is similar. Much more study material will be necessary to determine if this is a species complex with perhaps more than one species involved. The specimen collected in Kegalla District is the palest: yellow with antenna, apex of mandible, apical portion of terga 2–6, sheath, ovipositor, first segment of hindtrochanter, apical third of outer surface of hindtibia, and all hindtarsus black, and the forewing is yellow with only a faint black area beneath the stigma. The lectotype of *A. flavipennis* has most of the metasoma and hindtibia black and the forewing with the apex beyond the basal end of the stigma mostly black. The paralectotype of *A. flavipennis* is similar to the lectotype except the forewing has a large spot below the stigma and apical margin black, and the lectotype female and paralectotype male of *A. magnificus* Schletterer are similar to the paralectotype of *A. flavipennis.*



Figs. 5–8. *Pristaulacus signatus*. 5, Head, dorsal. 6, Mesosoma, dorsal. 7, Mesosoma, lateral. 8, Wings.

Pristaulacus signatus (Shuckard)
(Figs. 5–8)

Aulacus signatus Shuckard 1841: 124.—Westwood 1844: 268.—Schletterer 1890: 509 (= ? *stigmaticus* Westwood).—Kieffer 1902: 12 (? *Aulacus*).—Kieffer 1912: 373 (repeats Shuckard's description).—Hedicke 1939: 19.

Pristaulacus signatus: Kieffer 1904: 455 (? *Pristaulacus*).

Female.—Length, excluding ovipositor, 9–11 mm; forewing length, 8–10 mm; ovipositor length, 8–10 mm. Black except for following: mandible dark orange with apex reddish brown; anterior half or less of clypeus sometime brownish; antennal scape or scape and pedicel and fore- and midlegs beyond trochanters dark reddish; hindleg beyond coxae sometimes brownish; tegula brownish to reddish brown; first gastric segment sometimes partly pale reddish to orange. Wings hyaline; forewing with small infuscated spot below stigma (Fig. 8). Head from above short and narrowing behind eyes (Fig. 5); shining with widely scattered punctures and silvery hairs, these both more dense between ocelli and antennae; occipital carina short. Propleuron shining with scattered punctures, similar to top of head. Pronotum with a forward projecting triangular tooth just above its midlength; anterolateral angles of mesonotum protruding anteriorly in dorsal and lateral views and mesonotum with coarse transverse ridges; dense silvery hairs somewhat obscuring sculpture, especially laterally (mesosoma as in Figs. 6, 7). Hindcoxa with distinct, coarse transverse wrinkles laterally and posteriorly. Tarsal claws with 4 teeth, including apical tooth, and small basal lobe. Ovipositor length about as long as forewing length.

Male.—Length, 8–10 mm. Color and structure as for female.

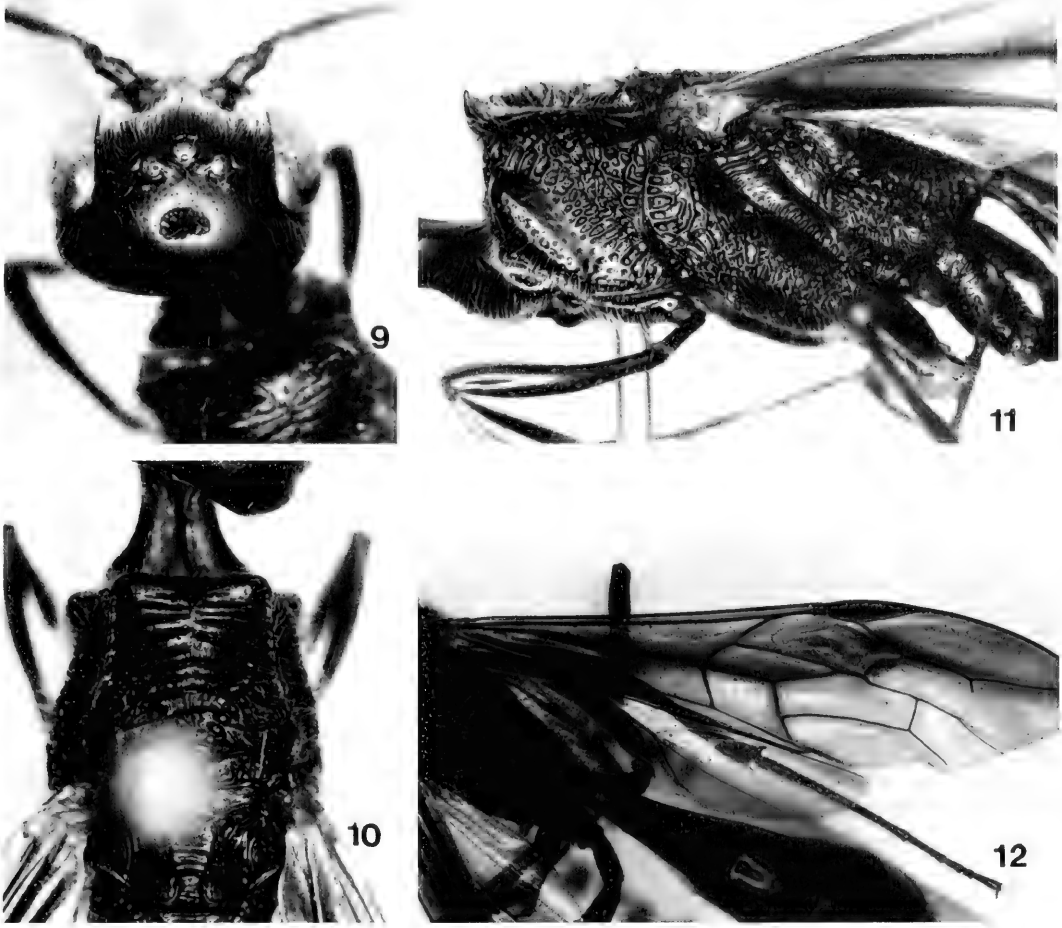
Records.—SRI LANKA: *Amparai District*, Ekgal Aru, 12-VI-1976, K.V. Krombein, P.B. Karunaratne, S. Karunaratne (1 ♀); Ekgal Aru, 100 mtrs, Reservoir Jungle, 19-22-11-1977, K.V. Krombein, P.B. Karunaratne, P. Fernando, D.W. Balasooryia (1 ♀), 11-12-VI-1976, K.V.Krombein, P.B. Karunaratne, S. Karunaratne (1 ♀); Lahugala Tank, 14-15-VI-1976, K.V.Krombein, P.B. Karunaratne, S. Karunaratne (1 ♀). *Anuradhapura District*, Padaviya Tank, 180 ft., 20-21-V-1976, K.V.Krombein, P.B. Karunaratne, S. Karunaratne, D.W. Balasooryia (1 ♀, 1 ♂); Padaviya, 180 ft., Irrigation Bungalow, 18-V-1976, K.V. Krombein, P.B. Karunaratne, S. Karunaratne, D.W. Balasooryia (1 ♀). *Colombo District*, Labugama, 23-24-VI-1975, S.L. Wood & J.L. Petty (2 ♀). *Kandy District*, Hasalaka, 140-170 m, 15-17-IX-1977, K.V. Krombein, P.B. Karunaratne, T. Wijesinhe, M. Jayaweera (1 ♀). *Kegalla District*, Kitulgala, Makande Mukalana, 3-4-II-1979, K.V. Krombein, P.B. Karunaratne, T. Wijesinhe, S. Siriwardane, T. Gunawardana (1 ♂). *Polonnaruwa District*, 25 mi NW Polonnaruwa, 11-VI-1975, S.L. Wood & J.L. Petty (2 ♀); N. Central Province, Ritigala Nat. Reserve, 8 mi NW Habarana 8-II-1962. Loc. 546:I, swept on grass in forest, Lund University Ceylon Expedition 1962, Brinck-Andersson-Cederholm (1 ♀). *Puttalam District*, 17 mi SE Puttalam, 18-VI-1975, S.L. Wood & J.L Petty (2 ♀). *Ratnapura District*, Uggalkaltota, 350′, 20-VI-1976, K.V. Krombein, P.B. Karunaratne, S. Karunaratne (1 ♀); Gilimale, Induruwa Jungle, 5-7-11-1977, K.V. Krombein, P. Fernando, D.W. Balasooryia, V. Gunawardane (1 ♀). *Trincomalee District*, China Bay Ridge Bungalow, 0-50 feet, 24-25-VII-1978, K.V. Krombein, T. Wijesinhe, V. Kulasekare, L. Jayawickrema (1 ♀, 2 ♂); Trincomalee, China Bay Ridge Bungalow, 25-50 ft., 26-II-1979, K.V. Krombein, T. Wijesinhe, S. Siriwardane, L. Jayawickrema, T. Gunawardane (2 ♀), 0-100′, 13-17-V-1976, K.V. Krombein, P.B. Karunaratne, S. Karunaratne, D.W. Balasooryia (1 ♀), 16-17-V-1976, same collectors (1 ♀); Trincomalee, China Bay, 1-30 m, 8-11-X-1977, collected near ridge bungalow, K.V. Krombein, P.B. Karunaratne, P. Fernando, T. Wijesinhe, M. Jayaweera (1 ♀), in Malaise trap, same date and collectors (1 ♀).

Type.—The type is presumably lost. It was not found in The Natural History Museum, London (A. Shinohara, correspondence).

Discussion.—Shuckard's type was not found. His description is very brief: "Niger: scapo antennarum pedibusque 4 anticis rufo-testaceis: alis hyalinis, macula ad stigma brunnea. Long. 5½ lin. Exp. alar. 9½ lin." The sex is not given and cannot be determined since both sexes are colored similarly. The specimens from Sri Lanka agree with Shuckard's description, and I regard them as *A. signatus*. This species appears to be the most widely distributed species in Sri Lanka and is easily separated from the other two species by the black color with the reddish scape, pedicel, and fore- and midlegs and structural characters as given in the key and as illustrated.

Pristaulacus krombeini Smith, new species
(Figs. 9–12)

Female.—Length, excluding ovipositor, 16 mm; forewing length, 13 mm; ovipositor length, 15 mm. Black; tegula reddish brown; anterior margin of clypeus, mandible except apex, tarsi, and lateral and ventral portions of first metasomal segment slightly brownish. Forewing with anterior



Figs. 9–12. *Pristaulacus krombeini*. 9, Head, dorsal. 10, Mesosoma, dorsal. 11, Mesosoma, lateral. 12, Wings.

half black, posterior half of forewing and hindwing more hyaline to slightly blackish; veins and stigma black (Fig. 12). Head from above short and narrowing behind eyes (Fig. 9); with widely scattered fine punctures and silvery hairs, each more dense between ocelli and antennae; occipital carina short. Propleuron shining with scattered punctures, similar to top of head. Pronotum with a forward projecting triangular tooth just above its midlength; anterolateral angles of mesonotum scarcely protruding and rounded in dorsal view, directed upward in lateral view, mesonotum with coarse transverse ridges; silvery hairs on mesosoma not obscuring sculpture (mesosoma as in Figs. 10, 11). Hindcoxa with coarse transverse wrinkles laterally, posterior surface almost devoid of wrinkles. Tarsal claws with 4 teeth, including apical tooth, and a small acute basal lobe. Ovipositor length about 1.2 × forewing length.

Male.—Unknown.

Holotype.—Female, labeled "Sri Lanka: Tri. [Trincomalee] Dist., Tennamaravadi, 18-V-1976, K.V. Krombein, P.B. Karunaratne, S. Karunaratne, D.W. Balasooryia." In the National Museum of Natural History, Washington, D.C.

Etymology.—Named for my colleague, Dr. Karl V. Krombein, Department of Entomology, Smithsonian Institution, Washington, D.C.

Discussion.—The forewing with the anterior half infuscated and the posterior half lighter black to hyaline, entirely black coloration, and structure of the mesonotum as shown in Figs. 10 and 11 separate this species from other Aulacidae described from southeastern Asia. A review of the descriptions of other species described from southeastern Asia, especially those from northern India and Indochina, revealed various distinguishing features from *P. krombeini*, especially combinations of coloration, wing maculation, and mesonotum structure. These taxa include *P. beesoni* Turner, *P. iridipennis* (Cameron), *P. nigripes* Kieffer, *P. rufobalteatus* Cameron, *P. rufobalteatus leviceps* Kieffer, and *P. bituberculatus* (Cameron) from the Himalayas of northern India, and *P. emarginaticeps* Turner, *P. excisus* Turner, *P. nigripes* var. *duporti* Kieffer, *P. tuburculiceps* Turner, and *P. tonkinensis* Turner from Indochina.

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NOTES ON LIFE HISTORIES AND DESCRIPTIONS OF ADULTS AND IMMATURE STAGES OF *PROCECIDOCHARES KRISTINEAE* AND *P. LISAE* NEW SPECIES (DIPTERA: TEPHRITIDAE) ON *AMBROSIA* SPP. IN SOUTHERN CALIFORNIA

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Abstract.—***Procecidochares kristineae*** **Goeden, n. sp.**, and ***P. lisae*** **Goeden, n. sp.**, are described and figured as adults and distinguished from each other by their wing patterns, chaetotaxy, and genal color and by these and additional characters from all other North American congeners. Sexually dimorphic wing patterns in *P. lisae* are reported for the first time from this genus. First through third-instar larvae and puparia also are described and figured for both species, but few morphological differences were found. *Procecidochares kristineae* and *P. lisae* are strictly monophagous tephritid flies forming axillary bud galls on branches of the native, shrubby, xerophytic ragweeds, *Ambrosia dumosa* (Gray) Payne and *A. eriocentra* (Gray) Payne (Asteraceae), respectively. Both are circumnatal species that overwinter as first instars within incipient galls in southern California. Further gall and larval development and host-plant regrowth and reproduction are stimulated concurrently by winter rainfall. Reproduction by *P. kristineae* is rarely biennial, usually univoltine or bivoltine, and rarely trivoltine, depending on local yearly rainfall patterns; whereas, *P. lisae* usually is univoltine or bivoltine.

Key Words: Insecta, *Procecidochares*, *Ambrosia*, ragweed, biology, galls, taxonomy of adults and immature stages, sexual dimorphism, parasitoid

Two undescribed species of *Procecidochares* (Diptera: Tephritidae) were detected during faunistic surveys of native ragweeds, *Ambrosia* spp. (Asteraceae: Ambrosiinae), in southern California by Goeden and Ricker (1976a, b). The life history of one species forming galls on *A. dumosa* (Gray) Payne was studied by Silverman and Goeden (1980), but it has remained unnamed until now. In this paper, both tephritid species are named, their adult and immature stages are described and illustrated, and new life-history information on each is reported.

Materials and Methods

Our field studies on the tephritid infesting *A. dumosa* were conducted near sea level in the low-elevation Colorado Desert (= northern Sonoran Desert) in southern California (Munz 1974) at various locations in Imperial, Riverside, and San Diego counties listed by Silverman and Goeden (1980) or mapped by Goeden and Ricker (1976a). Our principal study site for the fly on *A. eriocentra* (Gray) Payne was Mountain Pass at 1430-m elevation, San Bernardino Co., in the high-elevation, Mojave Desert; although this tephritid also was reared from galls obtained from surrounding locations named below in northeastern San Bernardino Co. during 1970–71 faunistic surveys (Goeden and Ricker 1976b). Galls containing eggs, larvae and puparia were sampled most recently from *A. dumosa* near Snow

Creek at 370-m elevation in the dry San Gorgonio River bed, Riverside Co., during February–April, 1993 and 1994, and from *A. eriocentra* at Mountain Pass during February–May, 1991-1995. Excised galls were transported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement. Twenty-one and 19 larvae and 4 and 3 puparia dissected from galls on *A. dumosa* and *A. eriocentra*, respectively, were preserved in 70% EtOH for scanning electron microscopy (SEM). All other fully grown larvae and puparia from *A. eriocentra* were placed in separate, glass shell vials stoppered with absorbant cotton and held in humidity chambers at room temperature for adult and parasitoid emergence. Specimens for SEM later were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH, critically point dried, mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia obtained from galls on *A. eriocentra* were individually caged in 850-ml, clear-plastic, screened-top cages with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. These cagings were used for longevity studies and oviposition tests in the insectary of the Department of Entomology, University of California, Riverside, at 25 ± 1°C, and 14/10 (L/D) photoperiod. Virgin male and female flies obtained from emergence vials as well as field-swept adults were paired in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey (Headrick and Goeden 1991) for direct observations, videorecording, and still-photography of their courtship and copulation behavior.

Plant names used in this paper follow Munz (1974); tephritid nomenclature and adult terminology follow Foote et al. (1993). Format used to describe the adults follows Blanc and Foote (1961). Morphological terminology and telegraphic format used to describe the immature stages follow Goeden and Headrick (1992), Headrick and Goeden (1990, 1993), Goeden et al. (1994a, b, 1995a, b), Goeden and Teerink (1996a, b, c), Headrick et al. (1995), and our other works cited therein. Means ± SE are used throughout this paper. The holotypes, allotypes, and five individually reared paratypes of each sex of both new species have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). Six additional, individually reared paratypes of each sex of both species also were deposited in the collection of the California Academy of Sciences (CAS). The holotype, allotype, and 22 paratypes used for measurements to describe *P. kristineae* originated from one collection in 1980 at the Palm Springs study site used by Silverman and Goeden (1980); the same numbers of types were used to describe *P. lisae* from one collection in 1981 at Mountain Pass. All remaining paratypes and voucher specimens not designated as paratypes and reared parasitoids of both tephritids reside in the research collections of RDG; preserved specimens of larvae and puparia are stored in a separate collection of immature Tephritidae maintained by JAT.

Results and Discussion

Taxonomy

The new species from *A. dumosa* described below as *P. kristineae* is most similar to *P. stonei* Blanc and Foote, which it was first misidentified as (Silverman and Goeden 1980). However, adults of these two species are distinguished below mainly on the basis of their wing characters, instead of those often lacking in swept or preserved specimens, e.g., distribution patterns of setae on the scutum, consistent with the philosophy embodied in the key to U.S. and Canadian species of *Procecidochares* in Foote et al. (1993). The new species from *A. eriocentra* described as *P. lisae* also is distinguished below primarily by wing characters. Accordingly, the following key couplets replacing couplets 1 and 5 in the key of Foote et al. (1993) enable one to distinguish these two new species:

1. Pterostigma lighter brown in basal fifth to half than in apical part; sometimes a second orbitalbristle 1a
– Pterostigma evenly brown; 1 pair orbital bristles 2
1a. Two orbital bristles, the second pair very small and delicate; basal and discal bands separate. . . . . *flavipes* Aldrich
– One pair of orbital bristles; basal and discal bands usually connected 1b
1b. Gena with prominent dark brown spot at ventral margin of eye; discal band not extended posterior to vein $A_1 + CuA_2$ in male, usually crossing it in female, but fading towards posterior wing margin; basal and discal bands broadly connected in cells c, sc, br, and bm . . . . lisae Goeden, n. sp.
– Gena with ocherous to pale brown spot at ventral margin of eye; discal band extending distinctly to posterior wing margin in both sexes; basal and discal bands narrowly connected in cell sc or br . . kristinae Goeden, n. sp.

Procecidochares kristineae Goeden, new species

(Figs. 1, 3–7)

Procecidochares stonei Blanc and Foote: Wasbauer 1972: 7 (in part, *Ambrosia dumosa* host record).

Procecidochares n. sp.: Goeden and Ricker 1976a: 49 (host record).—Silverman and Goeden 1980: 283–288 (host, gall description, California distribution, biology, behavior, seasonal history, parasitoids, predators, gall inquiline).—Foote et al. 1993: 318 (taxonomic status)

Female (Holotype).—*Head:* In profile 0.6 to 0.7 times as long as high, face and frons meeting at an angle of about 120°; parafacial 0.75 times as wide as third antennal segment; gena about 0.2 times as high as eye, which is 0.5 to 0.6 as wide as high; frons ocherous brown to yellow or white, at vertex 1.4 to 1.6 times as wide as eye in lateral view, 1.2 to 1.3 times as wide as length from vertex to lunule; lunule half as high as its width between the antennae; face yellow to white, pollinose, concave, but raised medially and protruding slightly at middle of oral margin; antenna yellow, pollinose, third segment sometimes ocherous brown along anterior margin and apex, arista ocherous brown to black, lightest basally. Usually 3-4 frontal bristles (rarely 5 or 6), all black; one pair of black orbital bristles; black genal bristle slender, situated immediately below lower curvature of eye; all postoculars white.

Thorax: Pleuron mostly shining dark brown to black, especially the katepisternum, but with a very sparse pollinosity on anepisternum; katepisternal bristle black, most other pleural setae rather long and white; wing base and anepimeron densely silver pollinose over a dark brown to black ground-color; lateral third of mesonotum, including postpronotal lobe, shining dark brown to black; a wide, silvery pollinose stripe on a shiny black ground-color occupying median third of mesonotum from anterior margin nearly to scutoscutellar suture, slightly widened at transverse suture and invested with short, white, blunt setae (sometimes appearing pale yellow) as follows: scattered ± uniformly over median pollinose strip, except for anterior half of presutural part of scutum, where confined to center and margins of strip, also encircling the lateral third of presutural part of scutum including along the transverse suture, and trailing posteriolaterad and posteriomediad in separate rows 3 to 4 setae-wide, the outer row narrowing and crossing the scutoscutellar suture to end in a cluster of 5 to 12 setae at base of anterior scutellar bristle. One dorsocentral bristle situated about halfway between transverse suture and level of the postsutural supra-alar bristle, and located on margin of median pollinose area; cluster of 5 to 8 short, white setae anteriorad of base of postsutural supra-alar bristle.

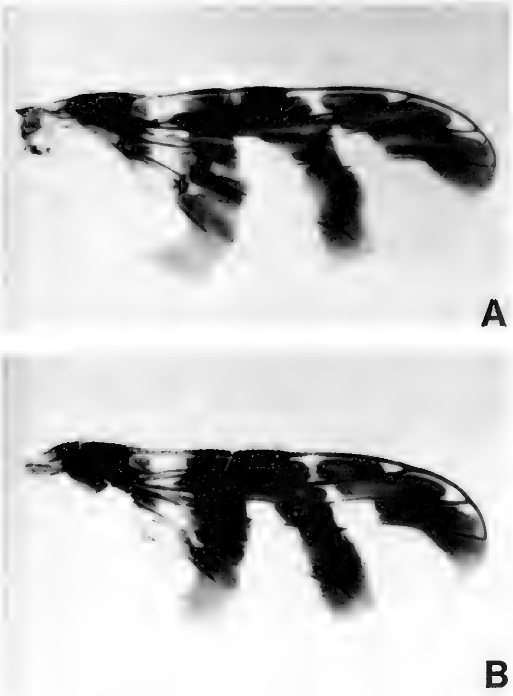

Fig. 1. Right wings of *Procecidochares kristineae:* (A) female; (B) male.

Scutellum shining dark brown to black, bulbous, two pairs scutellar bristles; postscutellum dark brown to black, pollinose. Haltere shaft ocherous yellow, slightly darker than knob. Femora of fore, mid, and hind legs dark brown but with yellow extremities, the remainder of legs yellow to ocherous yellow. Wing pattern as in Fig. 1A, B; pterostigma about 2.0 times as long as wide, lighter in basal fifth to third; basal and discal bands narrowly joined in cell br and/or sc, subapical and apical bands usually joined in cell(s) r_1 and/or r_{2+3} (Fig. 1A) or sometimes narrowly separated (Fig 1B) and only joined by darkened portions of veins R_{2+3} and R_{4+5}; distance between crossveins r-m and dm-cu measured along vein M about equal to length of r-m.

Abdomen: Dark brown to black, each tergum covered with white, flattened setae progressively increasing in length posteriorly. Oviscape shining dark brown to black, basal half slightly swollen, about half as long as all terga, except the first, taken together.

Male (allotype).—*Head:* Like ♀, but parafacial 0.67 times as wide as third antennal segment; frons at vertex 1.1 to 1.3 times as wide as one eye, 1.1 to 1.4 times as wide as distance from vertex to lunule; lunule 0.5 to 0.7 times as high as its width at antennal base. *Thorax:* Like ♀. *Abdomen:* Like ♀, only external genitalia dark brown to black.

Variation.—Examination of *P. kristineae* specimens with mostly intact setation confirmed variation in numbers of frontal setae, noted for the genus to vary from two to five by Foote et al. (1993). The holotype and 19 ♀ paratypes (68%) of a total of 28 ♀ types examined had three pairs of frontal setae; one pair of these setae was white in two ♀, and one pair was reduced in length and thickness in another ♀. One ♀ had four pairs of frontal setae; another ♀ had five pairs. The frontal setae were not strictly paired in the remaining six ♀, as four ♀ had three and four frontal setae on different sides of their heads; and each of two ♀, four and five frontal setae located asymmetrically. The allotype and 32 ♂ paratypes (64%) of a total of 50 ♂ types examined had three pairs of frontal setae. Three ♂ (6%) had four pairs of frontal setae. Among the remaining 15 ♂, nine (18%) had three and four frontal setae on different sides of their heads, four ♂ (16%) each had three and five frontal setae, and one ♂ each had four and five or four and six frontal setae located asymmetrically.

Regarding the wings, the subapical and apical bands also showed variation. The holotype and 14 ♀ paratypes (48%) of a total of 31 ♀ types with intact wings had the subapical and apical bands broadly joined (Fig. 1A); 7 ♀ paratypes (23%) had the subapical and apical bands narrowly joined in at least one wing (in the other wing in 5 of these ♀, these bands were narrowly separated, Fig. 1B); and in the remaining 9 ♀ (29%), these bands were narrowly separated in both wings. The allotype and 25 ♂

types (49%) of a total of 51 ♂ paratypes with intact, fully formed wings had the subapical and apical bands broadly joined (Fig. 1A); 8 ♂ paratypes (16%) had these bands narrowly joined in at least one wing (in the other wing in 1 ♂, these bands were narrowly separated); and in the remaining 18 ♂ paratypes (35%), these bands were narrowly separated in both wings.

Diagnosis.—The two main morphological characters distinguishing the adults of *P. kristineae* are the pterostigma being lighter brown in the basal fifth to third than in the apical part (Fig. 1), in combination with one pair of orbital setae. All types of *P. kristineae* possessed these two characters. The former character is shared only with *P. flavipes* and *P. lisae* (see below); the latter character distinguishes *P. flavipes* which has two pairs of orbital setae (Foote et al. 1993). *Procecidochares kristineae* and *P. lisae* are distinguished below. In the partial key provided above, if the pterostigmal character is missed *P. kristineae* will run to *P. stonei*, the only other species with basal and discal bands connected. Most *P. kristineae* differ from *P. stonei* by having the subapical and apical bands broadly to narrowly joined.

Of 179 reared voucher specimens of *P. stonei* with fully formed wings in the research collection of RDG (Green et al. 1993), 14 (8%) had a pterostigma in at least one wing that was light basally, but usually this basal area was small and only partially extended posteriorad across the cell, nor were the subapical and apical bands in the wings of these 14 flies joined. Similarly, another 12 voucher specimens of *P. stonei* had at least one wing with the subapical and apical bands joined, but all of these flies had pterostigmas that were evenly brown. Additional biological and ecological characteristics that distinguish *P. kristineae* and *P. stonei* are discussed below.

Types.—Holotype, ♀; 8 km NE of Palm Springs, 250-m elevation, Riverside Co., California; 26.ii.1981; R. D. Goeden, coll.(hereafter, RDG, coll.); reared from axillary bud gall on *A. dumosa* [at study site of Silverman and Goeden (1980)] (USNM); allotype, ♂, same data as holotype (USNM). Paratypes: CALIFORNIA: 12 ♂ and 24 ♀; same data as holotype (5 ♂ and 5 ♀ to USNM, 6 ♂ and 6 ♀ to CAS). 4 ♂ and 3 ♀; same location data as holotype; 10.ii.1971; RDG and D.W. Ricker, coll. (hereafter, RDG & DWR, coll.). 1 ♀; Twentynine Palms, San Bernardino Co.; 25.iii.1970; RDG & DWR, coll. 4 ♂ and 1 ♀; Llano, San Bernardino Co.; 30.iv.1970; RDG & DWR, coll. 6 ♂ and 1 ♀; Yucca Valley, San Bernardino Co.; 4.iii.1971; RDG & DWR, coll. 1 ♀; Borrego Springs, San Diego Co., 1.ii.1973; RDG & DWR, coll. 5 ♂ and 7 ♀; Valliceto Valley, S end of Smugglers Canyon at 442 m, San Diego Co.; 11.iii.1993; RDG and J.A. Teerink, coll. (hereafter, RDG & JAT, coll.). 5 ♂ and 4 ♀; Snow Creek at 370 m, Riverside Co.; 7.iv.1994; RDG & JAT, coll. 3 ♂ and 3 ♀; Ocotillo, Imperial Co., 2.ii.1995; RDG & JAT, coll. (Remaining 39 ♂ and 20 ♀ paratypes along with numerous swept and/or damaged-reared, voucher and nonvoucher specimens examined and identified are held in research collection of RDG).

Etymology.—*Procecidochares kristineae* is named for my younger daughter, Kristine Louise Gilbert (nee Goeden), mother of my two grandsons, Samuel Vanderpoel Gilbert V and Nikolaus Richard Gilbert.

Procecidochares lisae Goeden, new species

(Figs. 2, 8–12)

Procecidochares n. sp.: Goeden and Ricker (1976b): 927 (host record).

Female (holotype).—*Head:* In profile 0.5 to 0.6 times as long as high, face and frons meeting at an angle of about 120°; parafacial as wide as third antennal segment; gena with prominent, shiny, dark-brown spot from lower margin of eye to genal groove, gena 0.1 to 0.2 times as high as eye, which is 0.4 to 0.5 as wide as high; frons ocherous yellow to white, at vertex 1.3 to 1.7 times as wide as eye in lateral view, 1.3 to 1.6 times as wide as length from vertex to lunule; lunule 0.4 to 0.6 times as high as its width between the antennae; face pale yellow to white, pollinose, concave, but raised medially; antenna mostly brown, pollinose, apex of second segment and sometimes posterior margin of third segment yellow, arista ocherous yellow to brown, lightest basally. Usually, 3–4 frontal bristles (rarely 2 or 5), all black; one pair of black orbital bristles; genal bristle black, arising behind brown part of genal margin, which is extension of brown spot (noted above) below genal groove; all postoculars white.

Thorax: Pleuron mostly shining dark brown to black, especially the katepisternum, but with a very sparse pollinosity on anepisternum; katepisternal bristle black, most other pleural setae rather long and white; wing base and anepimeron densely silver pollinose over a dark brown to black ground-color; lateral third of mesonotum, including postpronotal lobe, shining dark brown to black; a wide, silvery pollinose stripe on a shiny black ground-color occupying median third of mesonotum from anterior margin nearly to scutoscutellar suture, slightly widened at transverse suture and invested with short, white, blunt setae (sometimes appearing pale yellow) as follows: scattered ± uniformally over median pollinose strip, except for anterior half of presutural part of scutum, where confined to center and margins of strip, also encircling the lateral third of the presutural part of scutum including along the transverse suture, encircling the anterolateral two-thirds of the scutum, and trailing posteriolaterad and crossing the scutoscutellar suture to end in a cluster of 8 to 18 setae at base of anterior scutellar bristle. One dorsocentral bristle situated just anterior to a line between the postsutural supra-alars and slightly laterad of the margin of median pollinose area. Scutellum shining dark brown to black, bulbous, two pairs scutellar bristles; postscutellum dark brown to black, pollinose. Haltere shaft ocherous yellow, slightly darker than knob. Femora of fore, mid, and hind legs dark brown but with ocherous yellow extremities, the remainder of legs yellow to ocherous yellow. Wing pattern as in Fig. 2A pterostigma about 2.0 times as long as wide, lighter in basal fifth to half; basal and discal bands broadly joined in cells c, sc, and br; discal band usually shortened, crossing cell cua$_1$ along and distal to vein CuA$_2$, and nearly or just touching vein A$_1$ + CuA$_2$ growing faint if extending into anal lobe; subapical and apical bands usually separated, or sometimes narrowly joined in cell(s) r$_1$ and/or r$_{2+3}$; distance between crossveins r-m and dm-cu measured along vein M about equal to length of r-m.

Fig. 2. Right wings of *Procecidochares lisae:* (A) female; (B) male.

Abdomen: Dark brown to black, each tergum covered with white, flattened setae progressively increasing in length posteriorad. Oviscape shining dark brown to black, basal half slightly swollen, about half as long as all terga, except the first, taken together.

Male (allotype).—*Head:* Like ♀, but about 0.6 times as long as high, face and frons meeting at an angle of about 110°; parafacial 0.67 times as wide as third antennal segment; eye 0.5 to 0.6 times as wide as high; frons at vertex 1.1 to 1.5 times as wide as eye, 1.3 to 1.7 times as wide as length from vertex to lunule; lunule 0.5 to 0.7 times as high as its width at antennal base. *Thorax:* Like ♀, but discal band of wing rarely extending into anal lobe and usually ending before and not touching vein A_1 + CuA_2; subapical and apical bands usually separated, but sometimes narrowly or widely joined in cell(s) r_1 and/or r_{2+3} (Fig. 2B). *Abdomen:* Like ♀, only external genitalia dark brown to black.

Variation.—Examination of *P. lisae* specimens with mostly intact setation further confirmed variation in numbers of frontal setae for the genus (Foote et al. 1993). The holotype and 30 ♀ paratypes (50%) of a total of 62 ♀ types examined had three pairs of frontal setae. Six ♀ paratypes (13%) each had four pairs of frontal setae; another ♀ had five pairs. The frontal bristles were not paired in the remaining 22 ♀, as 19 ♀ had three and four frontal setae on different sides of their heads; two ♀ had two and three frontal setae located asymmetrically; and one ♀ had three and six frontal setae so located. The allotype and 25 ♂ paratypes (53%) of a total of 47 ♂ types examined had three pairs of frontal setae. Eight ♂ paratypes (13%) each had four pairs of frontal setae. Among the remaining 13 ♂ paratypes, nine (19%) had three and four frontal setae on different sides of their heads; two ♂ (4%) each had two and three frontal setae, and one ♂ each had three and five or four and five frontal setae located asymmetrically.

Regarding the wings, the relationship of the subapical and apical bands showed variation. The holotype and 48 ♀ paratypes (69%) of a total of 71 ♀ types with intact wings had the subapical and apical bands fully separated (Fig. 2A); 13 ♀ paratypes (18%) had the subapical and apical bands narrowly separated; and in the remaining 9 ♀ (13%), these bands were narrowly or widely joined in cell r_1 in eight ♀ and one ♀, respectively. The allotype and 21 ♂ paratypes (45%) of a total of 49 ♂ types with intact, fully formed wings had the subapical and apical bands fully separated (Fig. 2B); 19 ♂ paratypes (39%) had these bands narrowly separated in at least one wing (in the other wing in four ♂, these bands were narrowly joined in cell r_1 or r_{2+3}); and in the remaining eight ♂ paratypes (16%), these bands were broadly joined in four ♂ or narrowly joined in four ♂ in cell r_1 or r_{2+3}.

In the holotype and 35 ♀ paratypes (51%) of the same 71 ♀ types with fully developed wings, the discal band extended across vein A_1 + CuA_2 into the anal lobe in both wings (Fig. 2A); in 27 ♀ paratypes (37%), this band ended at this vein in both wings; in two ♀ paratypes (3%) each wing showed a different one of these two characters. In only three (4%) of the remaining ♀ paratypes, the discal band ended before and did not reach vein A_1 + CuA_2. In the allotype and 39 ♂ paratypes (80%) of the same 49 ♂ types with intact, fully formed wings, the discal band ended before and did not touch vein A_1 + CuA_2 (Fig. 2B), or reached this vein in nine (18%) other ♂ paratypes, but crossed this vein into the anal lobe in only one ♂ paratype. These data, therefore, provide the first documented incidence of sexual dimorphism in the wing pattern of a species of *Procecidochares* (Foote et al. 1993); although, this dimorphism pales in comparison with wing pattern sexual dimorphism recently reported by us for certain species of *Aciurina* (Goeden and Teerink 1996a, b, c), or as long known for certain *Trupanea* spp. (Foote et al. 1993).

Diagnosis.—The incomplete discal band distinguishes *P. lisae* from all previously described species of *Procecidochares*. Two other characters distinguishing the adults of *P. kristineae* and *P. lisae* from other *Procecidochares* spp. are the pterostigma being lighter brown in the basal fifth to half than in the apical part, in combination with one pair of orbital setae. These species can then be readily separated on the basis of their wing patterns and the color of the genal spot as described in the partial key provided above. The pterostigmal character is shared only by *P. flavipes, P. kristineae,* and *P. lisae*, with *P. flavipes* separated by its possession of two pairs of orbital setae. The basal and discal bands are joined only in the wings of *P. kristineae, P. lisae*, and *P. stonei*, with *P. lisae* readily distinguished by the broad anterior juncture of these bands and by the shortened discal bands.

Types.—Holotype, ♀; Mountain Pass, 1430-m elevation, NE San Bernardino Co., California; 30.iv.1981; RDG, coll.; reared from axillary bud gall on *A. eriocentra* (USNM); allotype, ♂, same data as holotype (USNM). Paratypes: CALIFORNIA: 17 ♂ and 17 ♀; same data as holotype (5 ♂ and 5 ♀ to USNM, 6 ♂ and 6 ♀ to CAS). 5 ♂ and 1 ♀, 2 ♂ and 2 ♀; same location data as holotype; 19.iv.1971, 26.vi.1971, respectively; RDG & DWR, coll. 5 ♂ and 3 ♀, 2 ♀, 10 ♂ and 11 ♀; same location data as holotype; 9.v.1991, 9.v.1992, 9.v.1993, respectively; RDG & JAT, coll. 8 ♂ and 15 ♀; Halloran Springs, NE San Bernardino Co.; 19.iv.1971; RDG & DWR, coll. 3 ♀; Halloran Springs, NE San Bernardino Co.; 29.iv.1981; RDG, coll. 1 ♀, 1 ♂ and 1 ♀; Hackberry Mountain, NE San Bernardino Co.; 22.ix.1970, 4.iii.1971, respectively; RDG & DWR, coll. 3 ♂ and 4 ♀; Granite Cove, NW San Bernardino Co., 25.v.1971; RDG & DWR, coll. (Remaining 36 ♂ and 50 ♀ paratypes along with numerous swept and/or damage-reared, voucher and non-voucher specimens examined and identified are held in research collection of RDG).

Etymology.—*Procecidochares lisae* is named for my older daughter, Lisa Marie Goeden, a unique woman of many accomplishments.

Immature Stages

Procecidochares kristineae.—Egg: Eggs of *P. kristineae* (Fig. 3A, B), were described by Silverman and Goeden (1980). Chorion smooth (Fig. 3A); pedicel with few aeropyles (Fig. 3B).

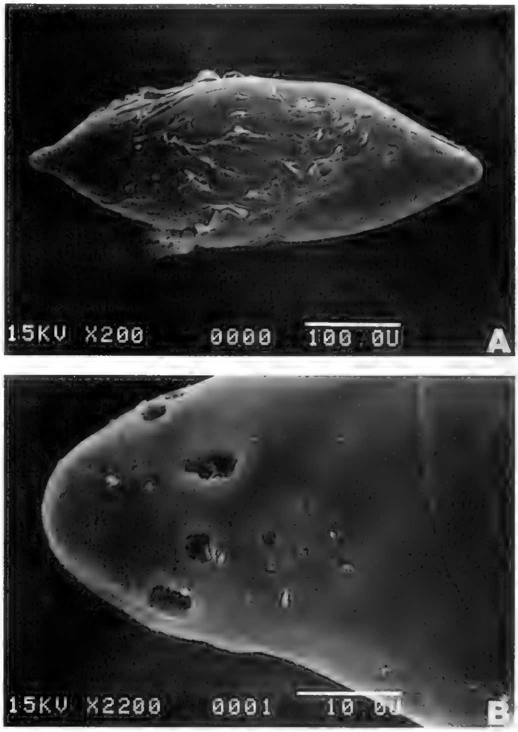

Fig. 3. Egg of *Procecidochares kristineae* (A) habitus; (B) anterior end, aeropyles.

Third instar: Superficially smooth, elongate cylindrical, tapering anteriorly, lacking minute acanthae (Fig. 4A); gnathocephalon conical, broad dorsally, smooth with few rugose pads (Fig. 4B); paired dorsal sensory organs dorsomediad of anterior sensory lobes, consisting of dome-shaped papilla (Fig. 4B-1, 4C-1); anterior sensory lobes bear terminal sensory organ (Fig. 4C-2), pit sensory organ (Fig. 4C-3), lateral sensory organ (Fig. 4C-4), and supralateral sensory organ (Fig. 4C-5); stomal sense organs ventrad of anterior sensory lobe (Fig. 4B-2); lateral sensillum ventrolaterad of stomal sense organs (Fig. 4B-3); mouth hooks tridentate, teeth conical, stout (Fig. 4B-4); median oral lobe fleshy, tapering anteriorly, attached to labial lobe (Fig. 4B-5); labial lobe with two pore sensilla; ventro-

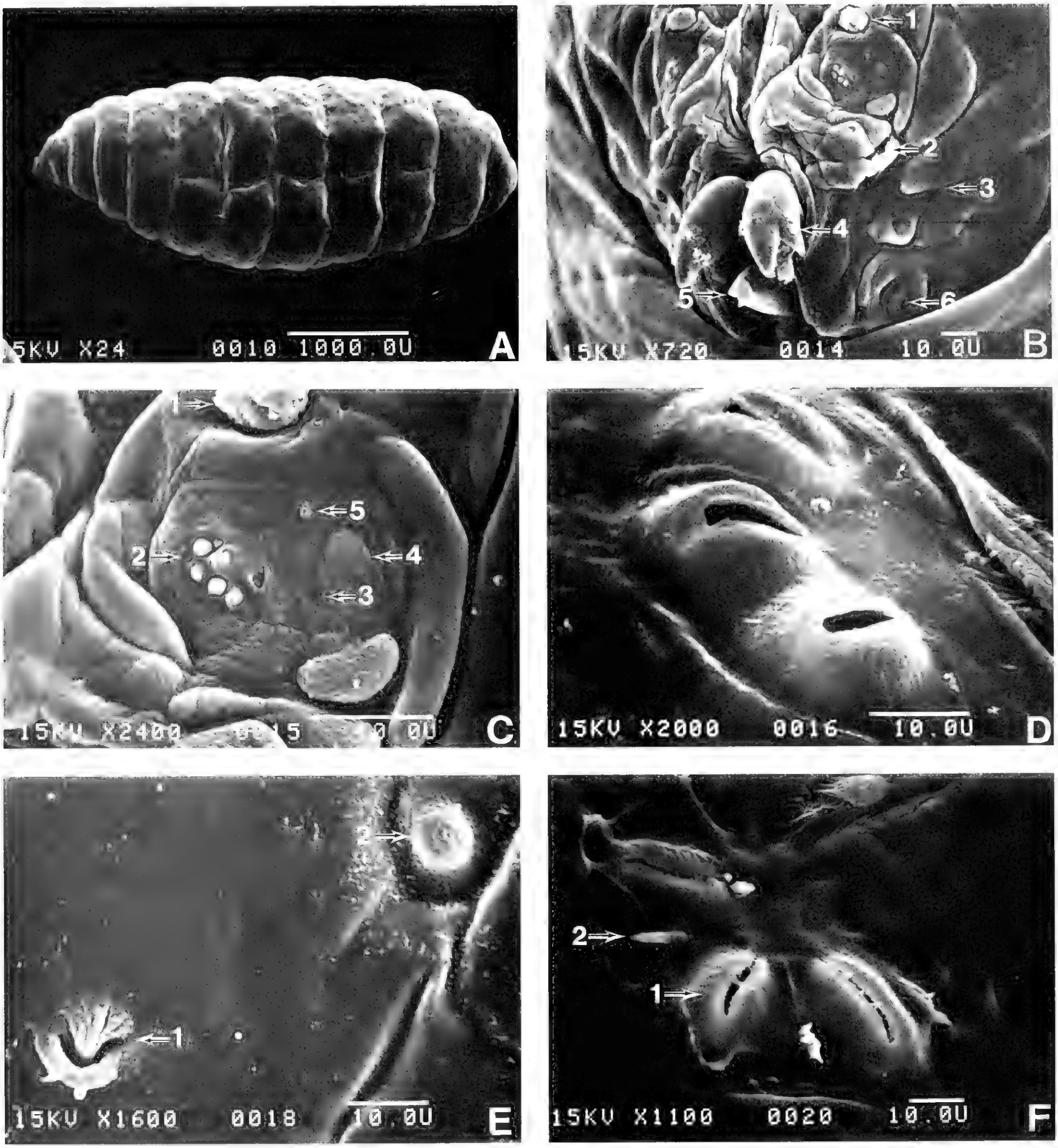

Fig. 4. Third instar of *Procecidochares kristineae:* (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—stomal sense organ, 3—lateral sensillum, 4—mouth hooks, 5—median oral lobe, 6—ventrolateral sensillum; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (D) anterior thoracic spiracles; (E) second abdominal lateral spiracular complex, 1—spiracle, 2—verruciform sensillum; (F) posterior spiracular plate, 1—rima, 2—interspiracular process.

lateral sensillum ventrolaterad of mouth lumen (Fig. 4B-6); prothorax smooth, verruciform sensilla circumscribe dorsal half of anterior margin, anterior thoracic spiracles on posterior margin consist of three ovoid papillae (Fig. 4D); meso- and metathoracic lateral spiracular complexes consist of an open spiracle; abdominal lateral spiracular complex consist of an open spiracle (Fig. 4E-1) and a single verruciform sensillum (Fig. 4E-2); caudal segment bears posterior spiracular plates (Fig. 4F);

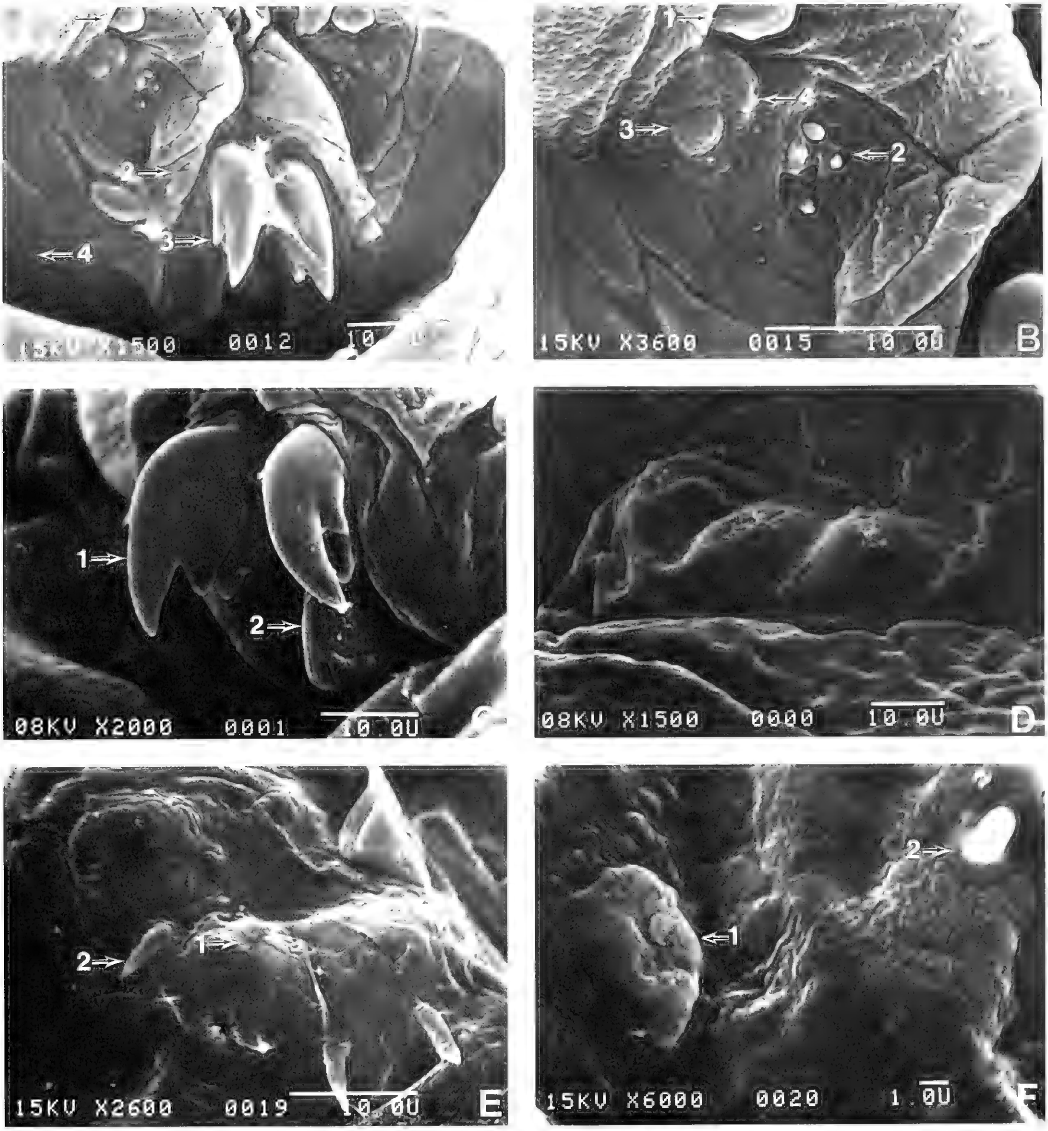

Fig. 5. Second instar of *Procecidochares kristineae:* (A) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—stomal sense organ, 3—mouth hooks, 4—ventrolateral sensillum; (B) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—lateral sensory organ, 4—supralateral sensory organ; (C) gnathocephalon, anteriolateral view, 1—mouth hooks, 2—median oral lobe; (D) anterior thoracic spiracles; (E) posterior spiracular plates, 1—rima, 2—interspiracular process; (F) compound sensillum, 1—verruciform sensillum, 2—stelex sensillum.

posterior spiracular plates with three ovoid rimae, ca. 0.024 mm in length (Fig. 4F-1), and four spiniform interspiracular processes, longest measuring 0.01 mm in length (Fig. 4F-2); compound sensilla ventrad of posterior spiracular plates consist of a verruciform sensillum and a stelex sensillum.

Second instar: Superficially smooth, barrel-shaped, rounded anteriorly and posteriorly; gnathocephalon conical, smooth with few rugose pads (Fig 5A); paired dorsal sensory organs consist of a dome-shaped papilla (Fig. 5A-1, B-1); anterior sensory lobe bears terminal sensory organ (Fig.

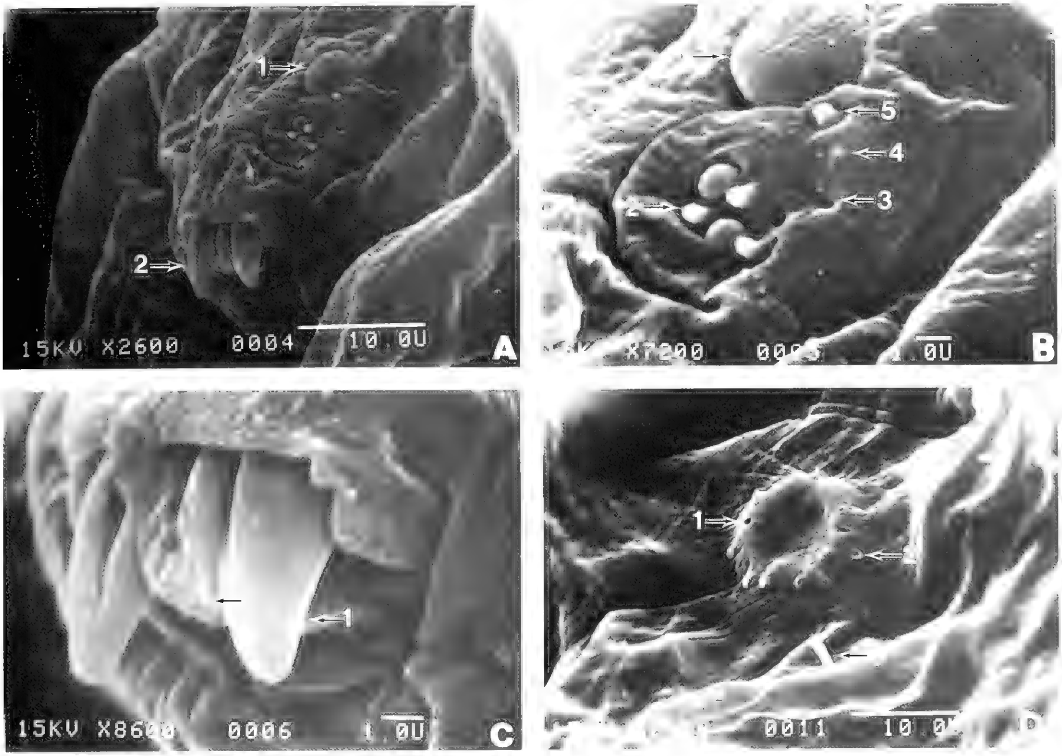

Fig. 6. First instar of *Procecidochares kristineae:* (A) gnathocephalon, anteriolateral view, 1—dorsal sensory organ, 2—mouth hooks; (B) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (C) gnathocephalon, anteriolateral view, 1—mouth hooks, 2—median oral lobe; (D) caudal segment, posterior spiracular plates, 1—rima, 2—interspiracular process, 3—stelex sensillum.

5B-2), pit sensory organ, lateral sensory organ (Fig. 5B-3), and supralateral sensory organ (Fig. 5B-4); stomal sense organ ventrad of anterior sensory lobe (Fig. 5A-2); mouth hooks tridentate, teeth conical, apical tooth longest (Fig. 5A-3, C-1); median oral lobe laterally flattened, rounded apically (Fig. 5C-2); ventrolateral sensillum ventrolaterad of mouth lumen (Fig. 5A-4); anterior thoracic spiracles on posterior margin of prothorax, consist of three ovoid papillae (Fig. 5D); lateral spiracular complex not observed; caudal segment bears posterior spiracular plates (Fig. 5E); posterior spiracular plates with three ovoid rimae, ca. 0.009 mm in length (Fig. 5E-1) and four spiniform interspiracular processes, longest measuring 0.005 mm (Fig. 5E-2); compound sensilla ventrad of posterior spiracular plates, consist of a verruciform sensillum (Fig. 5F-1), and a stelex sensillum (Fig. 5F-2).

First instar: Superficially smooth, barrel-shaped, rounded anteriorly and posteriorly, minute acanthae circumscribe segmental lines; gnathocephalon conical, smooth, lacking rugose pads (Fig. 6A); dorsal sensory organ consists of a dome-shaped papilla (Fig. 6A-1, B-1); anterior sensory lobes bear terminal sensory organ (Fig. 6B-2), pit sensory organ (Fig. 6B-3), lateral sensory organ (Fig. 6B-4), and supralateral sensory organ (Fig. 6B-5); stomal sense organs indistinct; mouth hooks bidentate, apical tooth with v-shaped frontal groove along entire length (Fig. 6A-2, 6C-1); median oral lobe rounded apically (Fig. 6C-2); anterior thoracic spiracles absent; lateral spiracular complexes not observed; caudal segment bears posterior spiracular plates (Fig. 6D); posterior spiracular plates with two ovoid rimae, ca. 0.002 mm (Fig. 6D-1), and four ovoid interspiracular processes, longest measuring 0.001 mm (Fig. 6D-2); stelex sensillum ventrad of posterior spiracular plates (Fig. 6D-3).

Puparium: Superficially smooth, elongate-ellipsoidal (Fig. 7A); anterior end bears invagination scar (Fig. 7B-1), and anterior thoracic spiracles (Fig. 7B-2); caudal segment bears posterior spiracular plates (Fig. 7C); posterior spiracular plates with three ovoid rimae, ca. 0.03 mm in length (Fig. 7C-1), and four spiniform interspiracular processes, longest measuring 0.01 mm (Fig. 7C-2). Measurements of *P. kristineae* puparia were provided by Silverman and Goeden (1980).

Procecidochares lisae.—Egg: Fifty ova of *P. lisae* were white, opaque, smooth; with an elongate-ellipsoidal body, 0.57 ± 0.005 (range, 0.52–0.64) mm long, 0.17 ± 0.002 (range, 0.16–0.20) mm wide, smoothly rounded at tapered posterior end; and with a short, peg-like anterior pedicel, 0.02 mm long by 0.03 wide.

Third instar: Superficially smooth, elongate cylindrical, tapering anteriorly, lacking minute acanthae (Fig. 8A); gnathocephalon conical, broad dorsally, smooth with few rugose pads (Fig. 8B); paired dorsal sensory organs dorsomediad of anterior sensory lobes, consisting of dome-shaped papilla (Fig. 8B-1); anterior sensory lobes bear terminal sensory organ (Fig. 8B-2), pit sensory organ (Fig. 8B-3), lateral sensory organ (Fig. 8B-4), and supralateral sensory organ (Fig. 8B-5); stomal sense organs ventrad of anterior sensory lobe; lateral sensillum ventrolaterad of stomal sense organs (Fig. 8B-6); mouth hooks tridentate, apical tooth longest (Fig. 8C-1); median oral lobe fleshy, laterally flattened, tapering anteriorly, (Fig. 8C-2); ventrolateral sensillum ventrolaterad of mouth lumen (Fig. 8C-3); prothorax smooth, verruciform sensilla circumscribe dorsal half of anterior margin; anterior thoracic spiracles consist of three ovoid papillae (Fig. 8D); meso- and metathoracic lateral spiracular complexes consist of an open spiracle; abdominal lateral spiracular complex consist of an open spiracle (Fig. 8E-1) and a single verruciform sensillum (Fig. 8E-2); caudal segment bears posterior

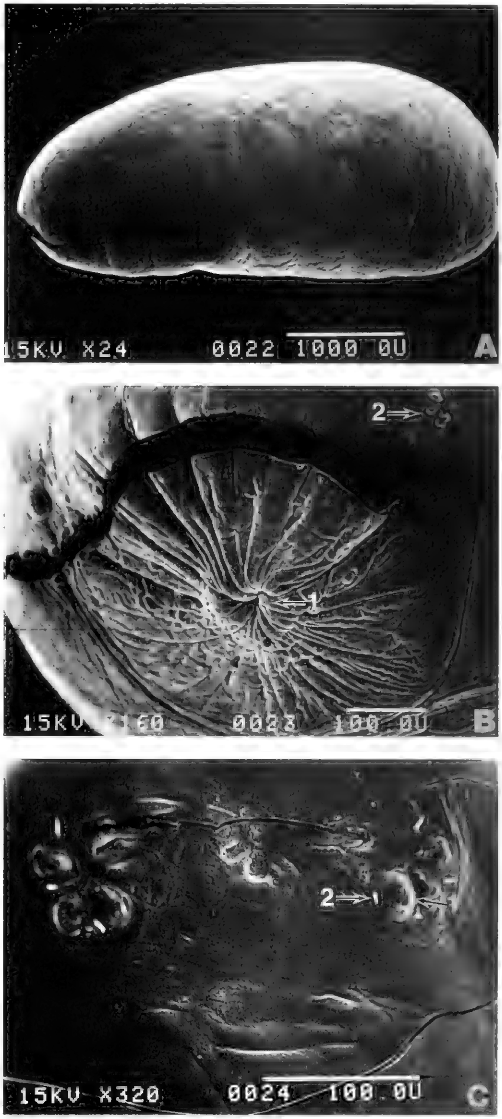

Fig. 7. Puparium of *Procecidochares kristineae:* (A) habitus, anterior to left; (B) anterior end, 1—invagination scar, 2—anterior thoracic spiracles; (C) caudal segment, posterior spiracular plates, 1—rima, 2—interspiracular process.

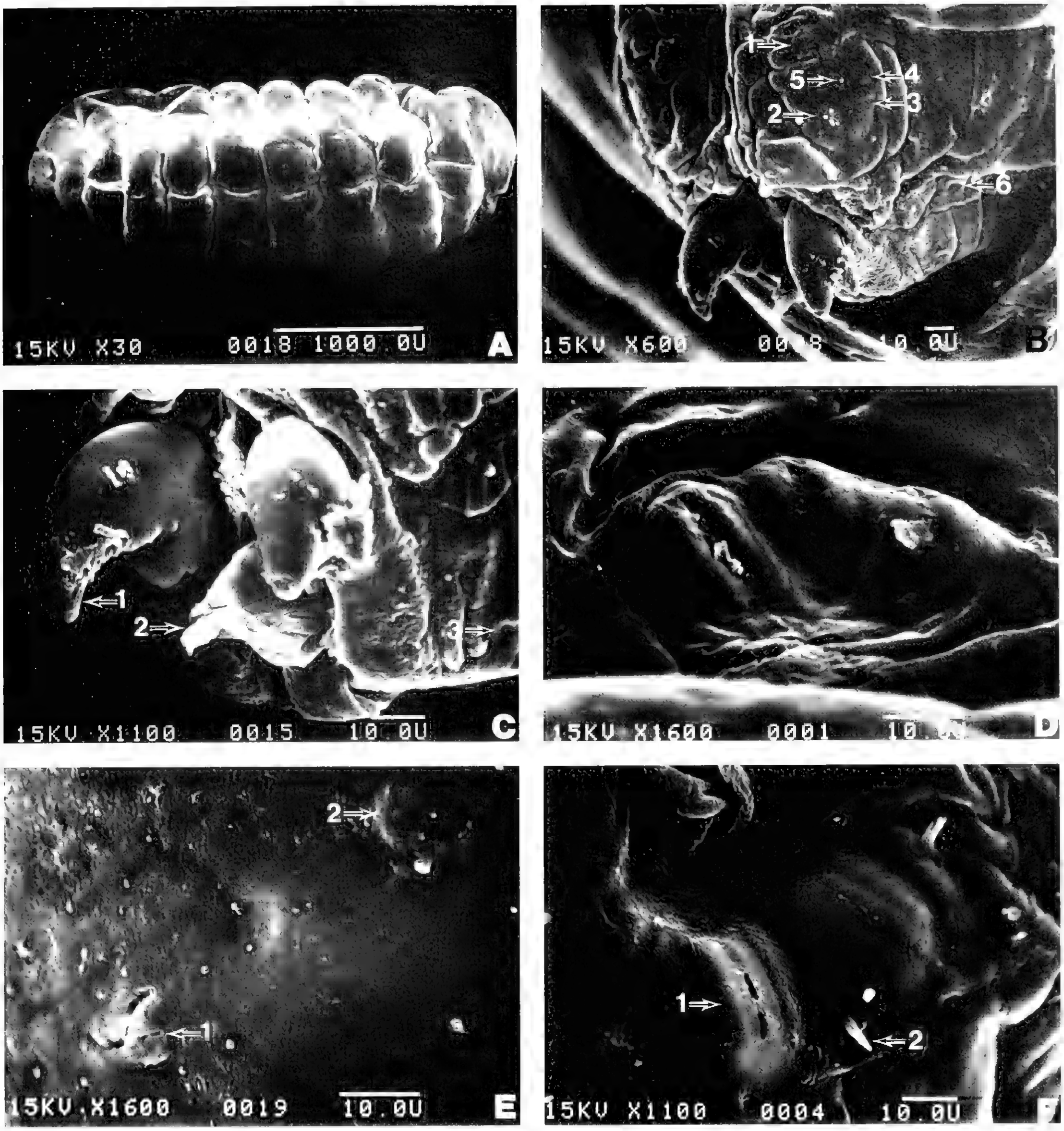

Fig. 8. Third instar of *Procecidochares lisae:* (A) habitus, anterior to left; (B) gnathocephalon, anteriolateral view, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ, 6—lateral sensillum; (C) gnathocephalon, anterior view, 1—mouth hooks, 2—median oral lobe, 3—ventrolateral sensillum; (D) anterior thoracic spiracles; (E) first abdominal lateral spiracular complex, 1—spiracle, 2—verruciform sensillum; (F) posterior spiracular plate, 1—rima, 2—interspiracular process.

spiracular plates; posterior spiracular plates with three ovoid rimae, ca. 0.025 mm in length (Fig. 8F-1), and four spiniform interspiracular processes, longest measuring 0.01 mm in length (Fig. 8F-2); compound sensilla ventrad of posterior spiracular plates consist of two verruciform sensilla.

Second instar: Superficially smooth, cylindrical, rounded anteriorly and posteriorly; gnathocephalon conical, smooth with few rugose pads; paired dorsal sensory organs consist of a dome-shaped papilla (Fig. 9A-1); anterior sensory lobe bear terminal sensory organ (Fig. 9A-2), pit sensory or-

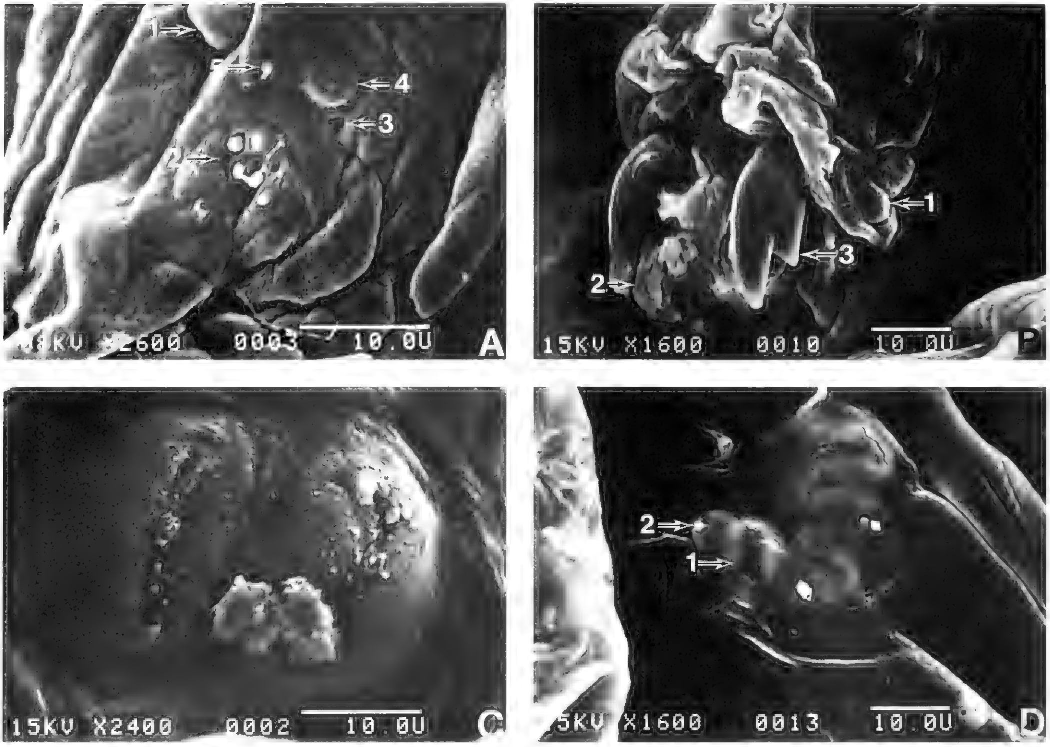

Fig. 9. Second instar of *Procecidochares lisae:* (A) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (B) gnathocephalon, anteriolateral view, 1—stomal sense organ, 2—median oral lobe, 3—mouth hooks; (C) anterior thoracic spiracles; (D) caudal segment, posterior spiracular plates, 1—rima, 2—interspiracular process.

gan (Fig. 9A-3), lateral sensory organ (Fig. 9A-4), and supralateral sensory organ (Fig. 9A-5); stomal sense organ ventrad of anterior sensory lobe (Fig. 9B-1); mouth hooks tridentate, teeth conical (Fig. 9B-3); median oral lobe fleshy, laterally flattened (Fig. 9B-2); anterior thoracic spiracles on posterior margin of prothorax, consist of two-three ovoid papillae (Fig. 9C); lateral spiracular complex not observed; caudal segment bears posterior spiracular plates; posterior spiracular plates with three ovoid rimae, ca. 0.009 mm in length (Fig. 9D-1) and four spiniform interspiracular processes, longest measuring 0.004 mm (Fig. 9D-2); compound sensilla ventrad of posterior spiracular plates were obscured in prepared specimens.

First instar: Superficially smooth, cylindrical, tapering anteriorly, rounded posteriorly, minute acanthae circumscribe segmental lines (Fig. 10A); gnathocephalon conical, smooth, lacking rugose pads (Fig. 10B); dorsal sensory organs large, dome-shaped (Fig. 10B-1, C-1); anterior sensory lobes bear terminal sensory organ (Fig. 10C-2), pit sensory organ (Fig. 10C-3), lateral sensory organ (Fig. 10C-4), and supralateral sensory organ (Fig. 10C-5); stomal sense organs indistinct; mouth hooks bidentate, apical tooth with v-shaped frontal groove along midline (Fig. 10B-2, D-1); ventrolateral sensillum ventrolaterad of mouth lumen (Fig. 10B-3, D-2); anterior thoracic spiracles absent; lateral spiracular complexes not observed; caudal segment bears posterior spiracular plates (Fig. 10E-1); posterior spiracular plates with two ovoid rimae, ca. 0.002 mm in length (Fig. 10F-1), and four, very reduced spiniform

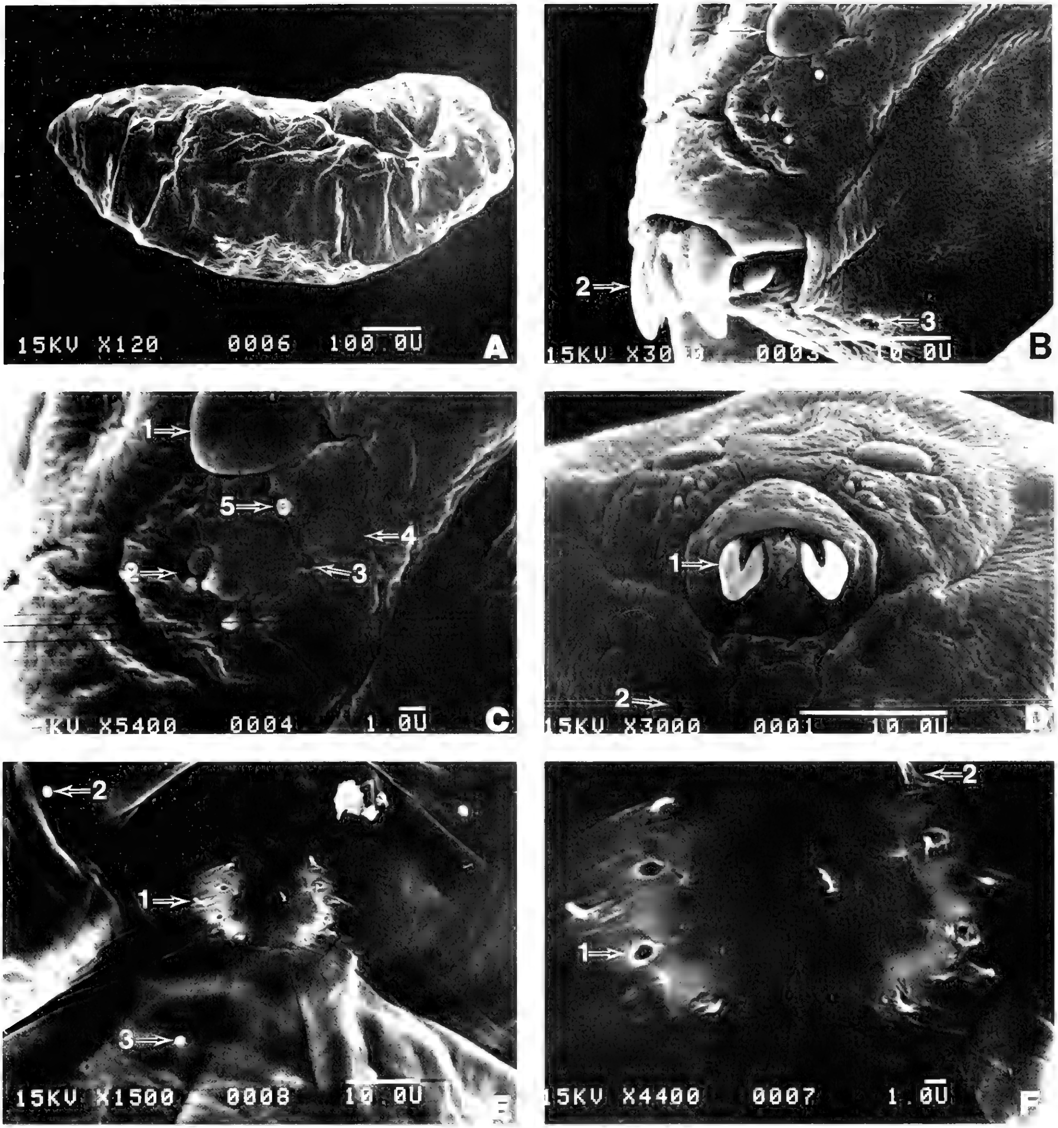

Fig. 10. First instar of *Procecidochares lisae:* (A) habitus, anterior to left; (B) gnathocephalon, lateral view, 1—dorsal sensory organ, 2—mouth hooks, 3—ventrolateral sensillum; (C) gnathocephalon, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (D) gnathocephalon, ventral view, 1—mouth hooks, 2—ventrolateral sensillum; (E) caudal segment, 1—posterior spiracular plates, 2—verruciform sensillum, 3—compound sensillum, verruciform sensillum; (F) posterior spiracular plates, 1—rima, 2—interspiracular process.

interspiracular processes, longest measuring 0.001 mm (Fig. 10F-2); two verruciform sensilla dorsolaterad of posterior spiracular plates (Fig. 10E-2); compound sensilla ventrad of posterior spiracular plates consist of two verruciform sensilla (Fig. 10E-3).

Puparium: Superficially smooth, elongate-ellipsoidal (Fig. 11A); anterior end bears invagination scar (Fig. 11B-1), and anterior thoracic spiracles (Fig. 11B-2); caudal segment bears posterior spiracular plates, each with three ovoid rimae, ca. 0.04

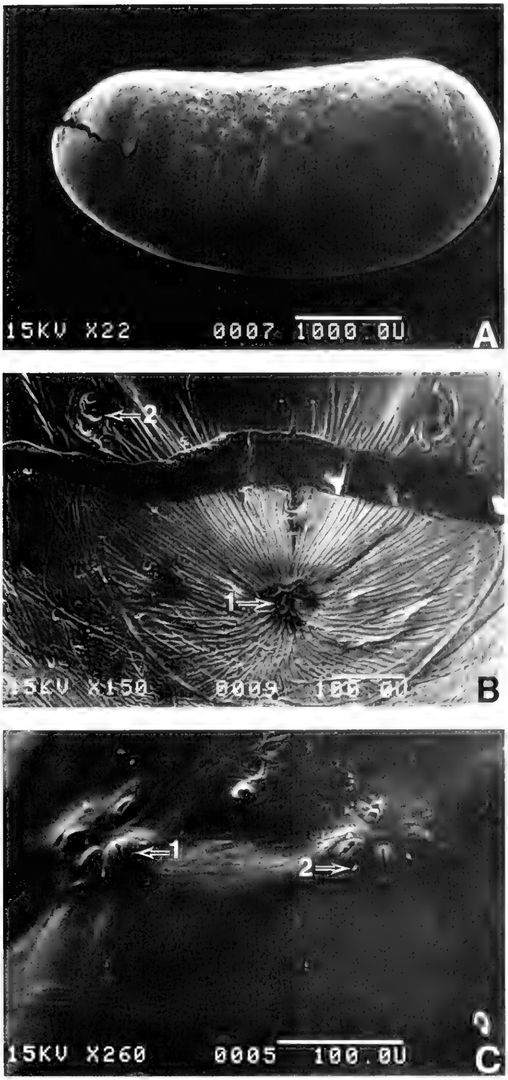

Fig. 11. Puparium of *Procecidochares lisae:* (A) habitus, anterior to left; (B) anterior end, 1—invagination scar, 2—anterior thoracic spiracle; (C) caudal segment, 1—rima, 2—interspiracular process.

mm in length (Fig. 11C-1), and four thorn-like interspiracular processes, longest measuring 0.007 mm (Fig. 11C-2). Fifty-six puparia averaged 4.01 ± 0.05 (range, 3.24-4.60) mm in length; 1.83 ± 0.03 (range, 1.40-2.35) mm in width.

Procecidochares kristineae and *P. lisae* larvae are morphologically very similar. The only difference noted was the compound sensilla ventrad of the posterior spiracular plates; in *P. kristineae* there was a verruciform sensillum and a stelex sensillum, but both sensilla in *P. lisae* were verruciform. Thus, morphological differentiation between these two, possibly sibling species on separate, closely related hosts is minimal between their larvae, but distinctive between their adults. Similar morphological differences between larvae and adults of two sympatric, nongallicolous, also probably sibling species, *Trupanea nigricornis* and *T. bisetosa* recently was reported (Knio et. al. 1996).

In turn, *Procecidochares kristineae* and *P. lisae* are very similar to *P. stonei* (Green et al. 1993). The noticeable difference between *P. stonei* and these two species in the third instar larva is that in the lateral spiracular complex, the verruciform sensillum is anteriorad of the spiracle in *P. stonei* not posteriorad. In the first instar of *P. stonei*, the mouth hooks are not grooved dorsally and the interspiracular processes are multi branched and blade-like (Green et al. 1993), not ovoid or spiniform and unbranched as in *P. kristineae* and *P. lisae*, respectively. *Procecidochares kristineae* and *P. lisae* are the first species of Tephritidae described with a v-shaped frontal groove in the apical tooth (Goeden and Headrick 1992; Goeden and Teerink 1996a, b, c; Goeden et al. 1994b; Green et al. 1993; Headrick and Goeden 1990; Headrick et al. 1995; Knio et al. 1996). The nongallicolous, flower head infesting species *P. flavipes* differs from all three of the above gall-forming species in having thoracic segments covered with small, polygonal rugose pads and the ventral intersegmental areas and dorsum of the caudal segment bearing minute acanthae (Goeden et al. 1994).

Distribution and Hosts

Both *Procecidochares kristineae* and *P. lisae* are true monophages, each forming galls only on its sole host-plant species, *Ambrosia dumosa* and *A. eriocentra*, respectively. *Procecidochares kristineae* is widely associated with *A. dumosa* in the Colorado and Mojave deserts of southern California (Goeden and Ricker 1976a, Silverman and Goeden 1980). Accordingly, the geographic distribution of *P. kristineae* may coincide wholly or partly with that of *A. dumosa* in southern Nevada, southwestern Utah, and western and southwestern Arizona (Benson and Darrow 1981), and southward into the Sonoran Desert of Baja California and Sonora, Mexico (Shreve and Wiggens 1964). The distributions of *P. lisae* and *A. eriocentra* in southern California are restricted to a small part of the northeastern Mojave Desert (Goeden and Ricker 1976b), but probably coincides wholly or partly with the wider distribution of this native ragweed in southern Nevada, southwestern Utah, and northwestern and central Arizona (Benson and Darrow 1981).

Estimating tephritid distribution from host-plant distribution is problematic because some gall-forming tephritid flies are known to be less widely distributed than their hosts, e.g., *A. bigeloviae* (Cockerell) and *A. trixa* Curran are widely allopatric, sympatric, or absent on *Chrysothamnus nauseosus* (Pallas) Britton in different parts of Utah, Arizona, New Mexico, and Colorado (Dodson and George 1986). Similarly, *A. trixa,* but apparently not *A. bigeloviae*, occurs in California on *C. nauseosus* which is a widespread plant species in southern California (D. H. Headrick, RDG, and JAT, unpublished data).

BIOLOGY

The biology of *P. kristineae* was described in considerable detail by Silverman and Goeden (1980). The following account largely concerns *P. lisae*, which then serves as a basis for comparison with *P. kristineae* and two other taxonomically-close *Procecidochares* spp. studied previously in southern California, *P. stonei* (Green et al. 1993) and *P. flavipes* (Goeden et al. 1994a).

Egg.—Most eggs are inserted singly and basally in axillary buds of the current season's branch growth. Some buds held two or rarely three eggs, presumably oviposited by different females, judging by the slightly different degrees of development of two or three first instars found associated with single buds in field-collected branch samples (see below). Two eggs of *P. kristineae* per axillary bud also were reported as rare by Silverman and Goeden (1980). Adjacent axillary buds of infested branches bore eggs probably deposited in sequence by individual females as they moved in sequence to the next more-proximal axils, as described for *P. kristineae* (Silverman and Goeden 1980).

Larva.—Eggs hatch about a week after their deposition (Goeden and Silverman 1980, Green et al. 1993), but then the first instar larvae persist as the longest-lived stage in the life cycle of *P. lisae* within tiny open cavities of incipient galls (Fig. 12A). Single, aestivating first instars were found overwintering in ovoidal cavities 0.74 ± 0.03 (range, 0.54–0.93) mm long by 0.54 ± 0.02 (range 0.37–0.74) mm wide formed within, beneath, or immediately laterad of 26 axillary buds. Four pairs each of these first instars were associated with single axillary buds, and three first instars with another bud, documenting again multiple ovipositions in single buds. Each of these larvae continued to develop separately, as all galls examined of *P. lisae*, like *P. kristineae* (Silverman and Goeden 1980), contained only one larva in each. Thus, sometimes two or rarely three unilocular galls of *P. lisae* arose at the same axil; although, only one gall per axil was usual for both *P. kristineae* and *P. lisae* (Silverman and Goeden 1980). However, larvae of *P. stonei* develop gregariously in unilocular galls (Green et al. 1993).

The aforementioned 26 galls were sampled on 7.ii.1995, so that not only were these aestivating first instars the overwintering stage of *P. lisae*, but also the stage within which this species had persisted for 6 or 7 months since the previous April or May, when their parent adults emerged, mated, and oviposited. Both *P. kristineae*

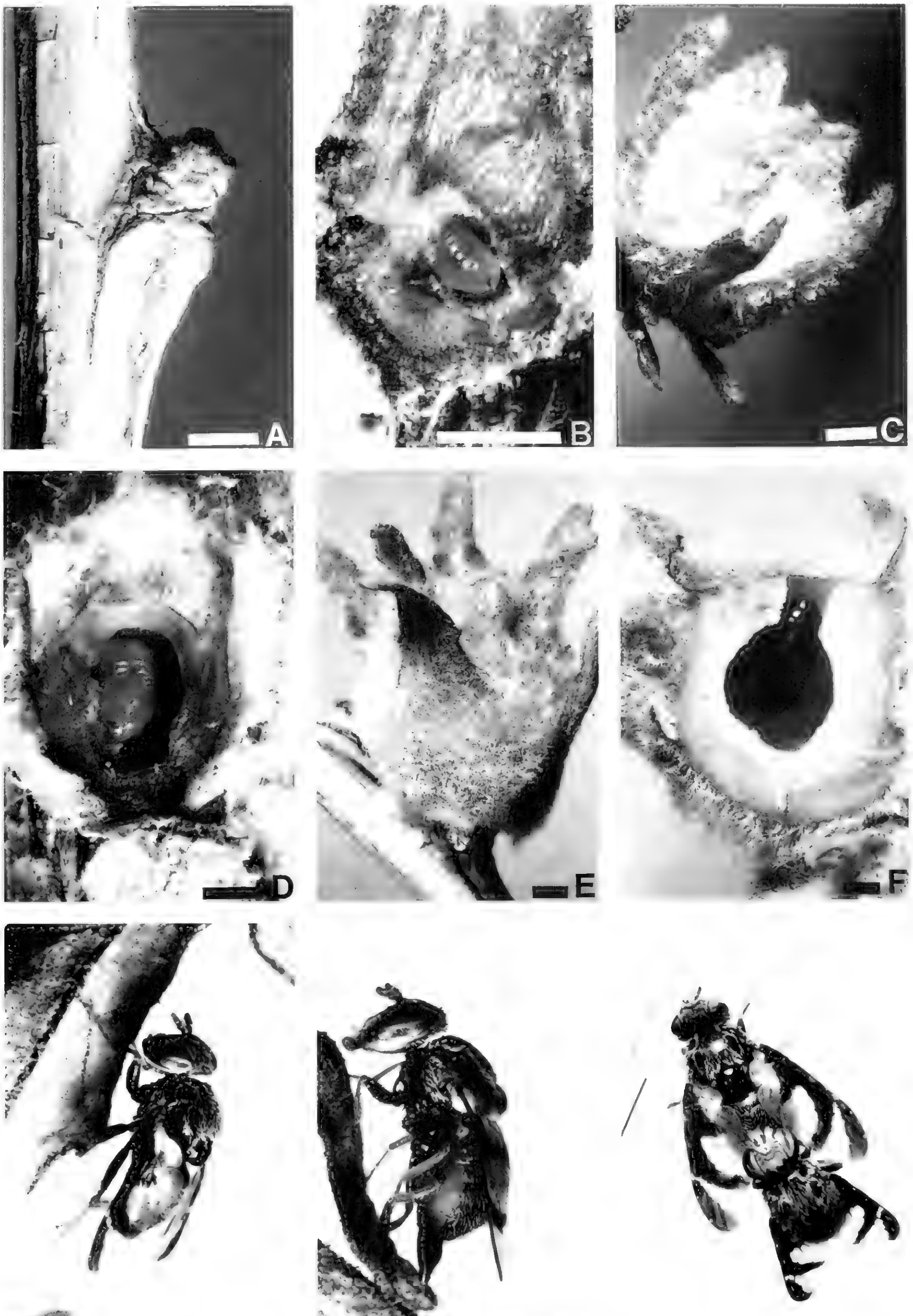

Fig. 12. Life stages of *Procecidochares lisae* on *Ambrosia eriocentra:* (A) axillary bud gall containing aestivating first instar, (B) sagittal section of preceding axillary bud gall, (C) axillary bud gall containing second instar, (D) sagittal section of gall containing second instar, (E) full-size gall, (F) sagittal section through full-size gall containing a puparium, and showing exit channel excavated by late third instar, (G) lateral view of male, (H) lateral view of gravid female, (I) mating pair, dorsal view. Lines = 1 mm.

and *P. stonei* also overwinter as first instars in incipient galls (Silverman and Goeden 1980, Green et al. 1993). The tiny, overwintering galls of *P. lisae* were undetectable in the field (Fig. 12A, B); although those of *P. kristineae* were readily discerned (Silverman and Goeden 1980). The former galls caused only a slight axillary swelling along the leafless branches of dormant *A. eriocentra*, unlike overwintering galls of *P. kristineae* on *A. dumosa* which incorporated juvenile leaves (Silverman and Goeden 1980). The axils on branches where incipient galls of *P. lisae* were borne averaged 3.04 ± 0.05 (range, 2.5–3.6) mm in diameter (n = 21) and were located an average of 15.8 ± 1.1 (range, 6–24.5) cm from branch apex.

Following substantial late-winter/early-spring rainfall, host plants, galls, and larvae of *P. lisae* concurrently resume growth as also reported for *P. kristineae* (Silverman and Goeden 1980) and *P. stonei* (Green et al. 1993). Twenty-five galls of *P. lisae* containing second instars (Fig. 12C, D) averaged 5.72 ± 0.35 (range, 2.41–11.40) mm in length; 5.44 ± 0.34 (range, 2.28–11.40) mm in width. These spheroidal galls (Fig. 12C) contained single, ovoidal to spheroidal cavities (Fig. 12D) that averaged 2.53 ± 0.21 (range, 1.14–5.70) mm in length and 1.97 ± 0.16 (range, 0.57–4.56) mm in width. The gall walls averaged 1.12 ± 0.10 (range, 0.42–2.85) mm in thickness.

The larvae of *P. lisae* quickly grew and molted into the third and last larval instar within mostly spheroidal galls (Fig. 12E, F), 21 of which averaged 8.0 ± 0.4 (range, 4.3–11) mm in length and 7.1 ± 0.3 (range, 4.2–10) mm in width. The central ovoidal or spheroidal cavities were enlarged by larval feeding to an average of 4.1 ± 0.2 (range, 1.42–5.13) mm in length and 3.17 ± 0.18 (range, 1.42–5.13) mm in width. The lateral wall thickness averaged 1.18 ± 0.04 (range, 0.57–2.15) mm. Prior to pupariation, the third instar chews an exit tunnel through the gall wall (Fig. 12F) ending in a thin, circular to oval, epidermal window 1.4 ± 0.04 (range, 1.2–1.7) mm (n = 13) in diameter.

Pupa.—Fifty-six galls containing puparia (Fig. 12F), and thus of maximum size and final subspheroidal shape, averaged 10.2 ± 0.4 (range, 3.9–16) mm in length; 8.9 ± 0.3 (range, 3.5–16) mm in width. The ovoidal to spheroidal cavities of these mature galls averaged 4.8 ± 0.2 (range, 3.1–3.4) mm in length; 4.0 ± 0.1 (range, 2.6–6.2) mm in width. The lateral walls of these galls averaged 1.58 ± 0.06 (range, 0.51–2.58) mm in thickness.

Adult.—The adults (Fig. 12G, H) of *P. lisae* that emerged from excised, field-collected galls were sexually mature, or nearly so, each female containing many full-size ova. These proovigenic females mated in laboratory cagings from 1 to 7 days-old (n = 35) (Fig. 12I). Ten males lived 11.5 ± 0.8 (range, 7–16) days; 11 nonovipositing females, 8.7 ± 0.7 (range, 5–12) days in insectary cagings. These mean longevities fell between the 1-week averages for *P. kristineae* (Silverman and Goeden 1980) and the 3-week averages for *P. stonei* (Green et al. 1993) under similar insectary conditions. This compares with longevities that averaged 42 days for males and 39 and 102 days for two series of synovigenic females (n = 11 and 20, respectively) of *P. flavipes* (Goeden et al. 1994a), which has an aggregative life cycle different from the circumnatal life cycles of *P. kristineae, P. lisae,* and *P. stonei* (Headrick and Goeden 1994).

The reproductive behavior of *P. lisae* resembled that of *P. kristineae* described by Silverman and Goeden (1980) and by D. H. Headrick from field observations (see below), and that of *P. stonei* described in greater detail by Green et al. (1993). Furthermore, a lack of courtship behavior and exclusive exhibition of enantion type of wing movements by both sexes reported by Headrick and Goeden (1994) as characteristic of circumnatal species of *Procecidochares* also was confirmed for *P. lisae.* Wing enantion as defined and described by

Green et al. (1993) and Headrick and Goeden (1994) was observed for *P. lisae* as males tracked females prior to copulation, during copulatory induction behavior, and following postcopulatory separation. Copulation by only one pair of *P. lisae* was observed from start to finish for 62 min, but nine more partially observed matings all were of shorter duration. Disengagement by three different pairs of adults was observed, whereby the males turned and walked off and away from the females as they concurrently pulled their genitalia from the females' cloacas in one continuous motion in 15, 18, and 30 sec, respectively. The wings of both sexes of *P. lisae* usually were parted at 45° and centered over their midlines during copulation; whereas, Silverman and Goeden (1980) reported that males of *P. kristineae* usually were only slightly parted during copulation, a position sometimes also adopted by *P. lisae* males.

Field observations.—Field observations of *P. kristineae* behaviors on *Ambrosia dumosa* were made by D. H. Headrick at Snow Creek, Riverside Co., 2–9 April 1992. Most observations were made for 1–3 h daily on three large shrubs all bearing newly formed, immature inflorescences.

The oviposition behavior of *P. kristineae* females was highly stereotypical. Each female began by walking from the base of a current season's branch to the base of the raceme, where she turned head-downward, recurved her abdomen and oviscape, and probed with the apex of the aculeus into a leaf axil. After ovipositing or probing, the female moved basally to the next leaf axil and probed or oviposited in the same manner. When the female reached the base of the new growth, she moved to another branch and repeated the above behaviors. Females probed many leaf axils, but oviposited into only 1 to 4 axils per branch. Oviposition times averaged 2 min 9 sec (n = 4; range, 2 min–2 min 20 sec). Females frequently stopped to rest and groom between ovipositions.

Mating behavior of *P. kristineae* was similar to that reported by Silverman and Goeden (1980). Males encountered females either while perched on top of branches or while moving through the crown. Males tracked females slowly from behind. Males sat still in a passive position if the female turned to face him, or paused nearby. Males mounted females by jumping onto their dorsa, either head first or from behind. Once mounted, males clasped the costal margins of the female's wings near the base with the foretarsal claws; the middle legs were wrapped around the middle of the abdomen of the female and the hind legs were bent and crossed underneath the abdomen of the female. Once mounted, males immediately began rubbing their hind legs asynchronously anterior to posterior underneath the abdomen of the female. Simultaneously, the abdomen of the female was raised and the apex of the ovipositor was placed into the epandrium; exsertion of the aculeus followed (n = 5). Copulation in the field lasted 30 min (n = 2).

Seasonal history.—*Procecidochares lisae* usually is univoltine, but occasionally, following substantial late-summer rainfall stimulating renewed host-plant growth, produces a facultative second generation. *Procecidochares kristineae* is normally bivoltine throughout its much wider range in southern California, but as reported by Silverman and Goeden (1980) can locally show univoltine, biennial, and even trivoltine reproduction (unpublished data), depending on whether rainfall locally triggers resumption of gall and larval development concurrent with host-plant regrowth. Both species, along with *P. stonei*, exhibit the circumnatal life cycle defined and described by Headrick and Goeden (1994).

Natural enemies.—The following chalcidoid Hymenoptera were identified as parasitoids of *P. lisae: Eurytoma* sp. and *E. veronia* Bugbee (Eurytomidae), as primary, solitary parasitoids reared from mature galls; *Halticoptera* sp. (Pteromalidae), as a primary, internal, larval-pupal parasitoid; *Tetrastichus* sp. (Eulophidae), as a gregarious, puparial endoparasitoid; *Torymus* sp. (*Bedeguaris* group), *Torymus* sp. (*Tubicola* group), *T. capillaceus* (Hüber) (Torymidae), probably as primary, solitary, larval ectoparasitoids as reared from immature galls.

Silverman and Goeden (1980) reported 10 species of parasitic Hymenoptera reared from fully formed galls of *P. kristineae*, an unidentified vertebrate predator of the larvae and identified spider predator of the adults, and two species of inquiline weevils. Green et al. (1993) subsequently reported four species of primary chalcidoid parasitoids individually reared from puparia of *P. stonei* as well as a hyperparasitized larval parasitoid. The genera of parasitoids common to all three *Procecidochares* hosts were *Eurytoma, Halticoptera,* and *Tetrastichus.*

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LIFE HISTORY AND LABORATORY REARING OF *OEDANCALA DORSALIS* (SAY) (HETEROPTERA: LYGAEIDAE), WITH DESCRIPTIONS OF IMMATURE STAGES[1]

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Abstract.—The life history of the seed bug *Oedancala dorsalis* (Say) was investigated in southern Illinois from June 1994–November 1995, and the immature stages were described. The bug also was reared from egg to adult under controlled laboratory conditions. This apparently bivoltine species fed and reproduced on *Carex* spp. Adults overwintered and became active in April. Eggs were found from mid-May to early September in the spikes of *Carex crinita*. Seasonal occurrences of adults and nymphs are discussed. Adults were last observed in mid-October. This species was reared on *C. crinita* in the laboratory at 26 ± 0.5°C under a 16L:8D photoperiod. The incubation period averaged 13.32 days. The five nymphal stadia averaged 6.34, 5.28, 4.52, 4.02, and 5.52 days, respectively.

Key Words: Seed bug, Lygaeidae, southern Illinois, life history, laboratory rearing, immature stages, descriptions, *Carex*

The family Lygaeidae contains approximately 4050 species worldwide (Slater and O'Donnell 1995). Next to the family Miridae, it is the second largest family of Heteroptera in America north of Mexico, where it is represented by approximately 320 species (Ashlock and Slater 1988). Lygaeids are commonly called seed bugs, referring to their habit of feeding on dry, mature seeds (Sweet 1960).

In the United States and Canada, the lygaeid subfamily Pachygronthinae contains the three genera *Oedancala* Amyot and Serville, *Pachygrontha* Germar, and *Phlegyas* Stål (Ashlock and Slater 1988). Only five species of *Oedancala* occur within this geographic area (Ashlock and Slater 1988, Baranowski and Slater 1989). Of these, *O. dorsalis* Say is the most widespread, ranging from Ontario, Quebec, and Maine south to Florida, and west to South Dakota, Colorado, and Texas, and is the only species of the genus that has been reported from Illinois (Ashlock and Slater 1988, Baranowski and Slater 1989).

Oedancala dorsalis has been little studied. It has been swept from herbage in wet meadows, pastures, and waste places (Blatchley 1926), and reported to feed on *Carex*, *Cyperus* (Van Duzee 1888, Slater 1951), *Ceanothus*, and marsh grasses (Slater 1951). Van Duzee (1888) found adults from May to September "about" Buffalo, New York. Uhler (1887) stated it rarely was found later than early summer in eastern North America and felt it was "single brooded." It overwinters under leaves and around the tussocks at the edges of swamps (Torre-Bueno 1925); small colonies have been found beneath logs along the borders of woodlands in late October (Blatchley 1926).

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[1] Part of a thesis submitted to Southern Illinois University at Carbondale by the senior author in partial fulfillment of the requirements for the M.S. degree in zoology.

This lygaeid has been reared in the laboratory under unspecified conditions and the egg and nymphal instars, except the second, have been described (Slater 1951).

In this paper, we present information on the field life history in southern Illinois and laboratory rearing of *O. dorsalis* and describe the immature stages.

MATERIALS AND METHODS

Field life history.—During summer 1994, several adults were observed feeding and copulating on the spikes of *Carex crinita* Lamarck in the La Rue-Pine Hills Research Natural Area, Union County, IL. The site is located along the south side of Forest Road 345, approximately 1.25 miles (2.01 km) east of State Highway 3. The plants (approximately 80 individuals) were growing at the bases of red maple (*Acer rubrum* L.) located at the edge of La Rue Swamp. The population of *O. dorsalis*, although small, seemed sufficiently large to permit a life history investigation of the bug. Therefore, a study was conducted from June 1994 to November 1995. Counts of all nymphs and adults observed in the field, and notes on their activity, were taken weekly from early April to early November, before the bugs emerged from and after they entered overwintering sites, respectively. Specimens were collected by hand picking. Nymphs large enough to be identified to instar, and adults, were released. Others were preserved in 70% ethanol and taken to the laboratory for closer examination. Also, five *C. crinita* staminate spikes were taken to the laboratory weekly and inspected for eggs.

Species of *Carex*, other than *C. crinita*, that served as host plants were noted from Pine Hills; Oakwood Bottoms, Jackson Co.; and Lake on the Campus, Southern Illinois University at Carbondale, Jackson Co. Bugs were recorded as feeding if their rostra were inserted in seeds or if many individuals were on the same plant.

Potential overwintering sites (e.g., leaf litter, under bark of fallen trees) were examined periodically during November–March.

Laboratory rearing.—Ten adults were collected on 17 May and on 24 May 1995, brought to the laboratory, and placed in two oviposition cages (5 males, 5 females/cage). Each cage consisted of a 1-quart (approximately 0.95-liter) Mason jar with a disc of moistened filter paper on the bottom. A pistillate spike of *C. crinita* (collected outside the study site) served as food and was inserted in a vial (8.5 cm length, 2.3 cm diam at base) containing distilled water stoppered with cotton; the vial was placed upright in the bottom of the cage. The cage was closed with a disc of paper toweling and wire screening secured with the band of the two-piece Mason jar lid. A strip of paper toweling (approximately 3 × 20 cm), which provided additional area for excrement absorption, was placed inside the jar with one end over the lip and held in place by the band.

The cages were examined daily for eggs, which were removed and placed on moistened filter paper in the bottom of a petri dish (approximately 9 cm diam., 2 cm depth) and covered with the lid. A thin layer of petroleum jelly was applied to the inside of the rim to help prevent the first instars from escaping. Additionally, the lids were secured with two strips of masking tape to insure a tight fit.

Nymphs (including the firsts) were kept in petri dishes prepared similarly to those for eggs (e.g., a ring of petroleum jelly); a section of a pistillate spike served as food. The nymphs were grouped by molting dates to accurately determine the stadia.

Food and filter paper in the cages and jars were changed, and distilled water was added, approximately every 2–3 days; the exception to this was that once oviposition began, spikes in the cages were replaced daily because they were destroyed during examination for eggs.

To obtain information on reproductive behavior and fecundity (fertility was determined in laboratory rearing), field-collected fifth instars were brought to the laboratory and placed in Mason jars prepared similarly to oviposition cages. As they reached adults, they were segregated by sex in two additional Mason jars. At the end of a minimum of two weeks, six pairs were placed in petri dishes (one male, one female/dish) prepared similarly to those used for nymphs but without the ring of petroleum jelly. Behavioral observations were made for periods of 1–2 hours.

All specimens were kept in incubators maintained at 26±0.5°C and a 16L:8D photoperiod (approximately 2800 lux).

Descriptions of immature stages.—The description of each stage is based on ten individuals. Eggs and first through fifth instars were selected from field collected and laboratory reared individuals; all had been preserved in 70% ethanol. Only those that had not swelled in the alcohol were used in the descriptions. Drawings were made with the aid of a camera lucida. Measurements, in mm, were made with an ocular micrometer.

Statistics.—Averages are expressed as $\bar{x} \pm$ SE; standard errors of less than 0.005 are listed as 0.00. Total developmental periods for males and females were compared with Student's t-test; level of significance was 0.05.

RESULTS AND DISCUSSION

Field life history.—*Oedancala dorsalis* overwintered as adults that became active in late April (Figs. 1, 2), began feeding and copulating on spikes of maturing *Carex crinita*, and reproduced shortly thereafter; it remained on the host into October. Adults and nymphs also fed on *C. blanda* Dewey, *C. cephalophora* Muhlenberg, *C. comosa* F. Boott, *C. conjuncta* F. Boott, *C. crus-corvi* Shuttleworth, *C. frankii* Kunth, *C. granularis* Muhlenberg, *C. squarrosa* L., *C. tribuloides* Wahlenberg, *C. vulpinoidea* Michaux, and *C. vulpinoidea* var. *ambigua* F. Boott (= *C. annectens* Bicknell) (Table 1). One adult and two nymphs were observed on *C. lurida* Wahlenberg and *C. lupulina* Muhlenberg, respectively, but were not observed feeding.

Eggs were found on *C. crinita* from mid-May to early September. They usually were laid singly, but, sometimes, they were deposited side by side in clusters of 2–5. Generally, they were inserted between the scales of staminate spikes; occasionally, they were found in pistillate spikes inserted between the scale and perigynium. Similar ovipositional behavior has been observed in other species of *Oedancala* (Baranowski and Slater 1982, 1989).

The first instars were found from early June to early September (Figs. 1, 2). They were observed most commonly near the bases of the staminate spikes with their yellowish orange abdomens protruding from between the perigynia. Second instars were found from mid-June to early September, third instars from mid-June to early October, fourth instars from late June to mid-October, and fifth instars from early July to early October. Second instars through adults were observed most commonly clinging to the pistillate spikes, feeding on seeds. If disturbed, nymphs often would fall to the ground and remain motionless; adults sometimes would fly a short distance to another plant or to the ground.

The mating position was end-to-end. No precopulatory behavior was observed in the field. Copulating adults were noted from late May to late June and from mid-July to early August. Other than mating, little interaction between individuals was observed.

Although adults clearly overwinter, no individuals were located in the field between November and March. Overwintered adults were most abundant from late May to early July and died off soon thereafter. New adults appeared in late July as evidenced by the appearance of callow adults (N = 6) and rise in number of adults following the first peak of fifth instars. Based on the peaks of abundance of the adults, eggs, and the first-fifth instars (Figs. 1, 2), and the two periods of copulation (see

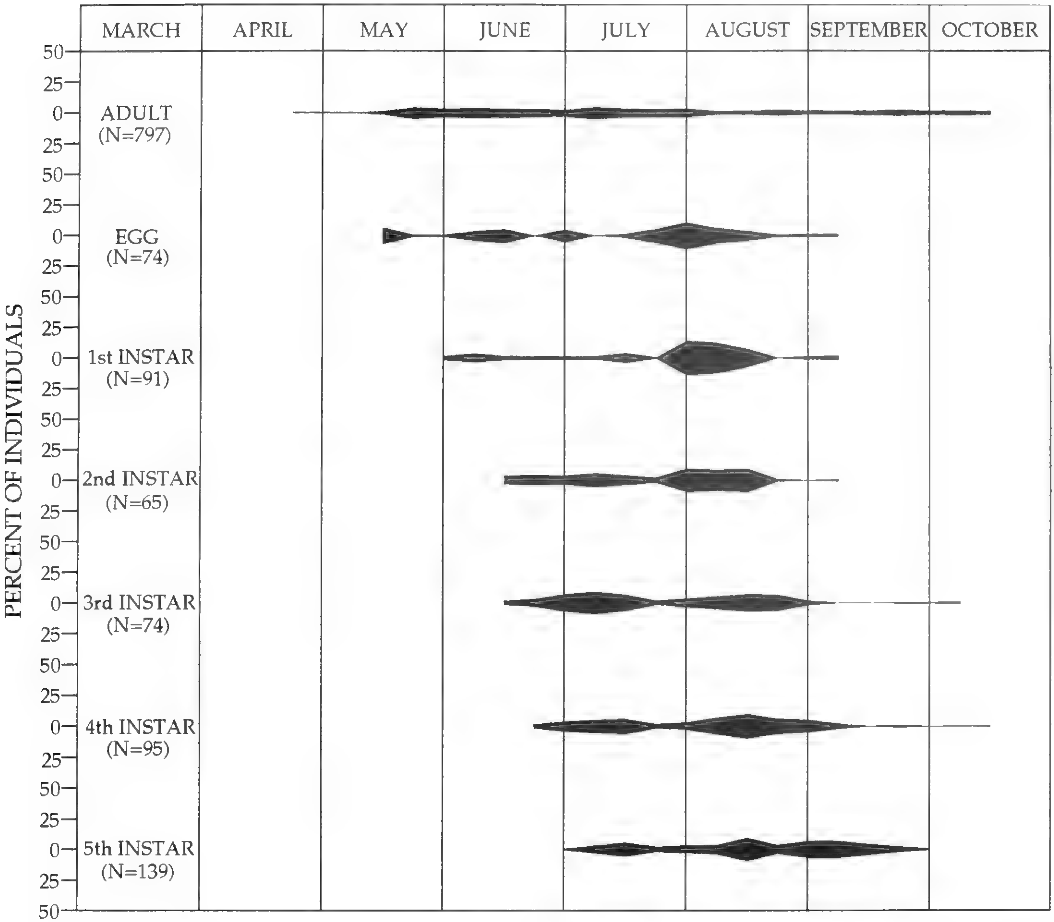


Fig. 1. Field cycle of *Oedancala dorsalis*. Percent in each sample of total individuals of same stage collected during 1995 season in Union Co., IL.

above), *O. dorsalis* apparently was bivoltine in southern Illinois.

Laboratory rearing.—Adults fed and copulated on the pistillate spikes of *C. crinita*. Of the 697 eggs laid during this study, 90.2% were inserted in the pistillate spikes between the scales and perigynia and 1.1% in the filter paper, and 7.8% were laid on the cotton and 0.9% on the sides of the jar. Most were laid singly (68.1%) or side by side in clusters of 2 or 3 (28.0%), less commonly in clusters of 4–7 (3.9%).

The incubation period averaged 13.32 days (Table 2). Eggs were pale green when laid, turning yellowish in 2–3 days. Pink eyespots were visible in 5 to 6 days. At this time, the anterior half of the egg began to redden; the posterior half remained yellowish. The minute egg burster and the paired dorsal sclerites of the abdomen were visible in 8 days.

The first instar emerged through a slit in the cephalic end of the egg. The ground color was yellowish just after emergence; the sclerotized areas were pink but darkened to brown within 3–5 hours.

The first, second, third, fourth, and fifth stadia averaged 6.34, 5.28, 4.52, 4.02, and 5.52 days, respectively. The total developmental period was 39.00 days (Table 2). There was no significant difference between total developmental period for males (37.34

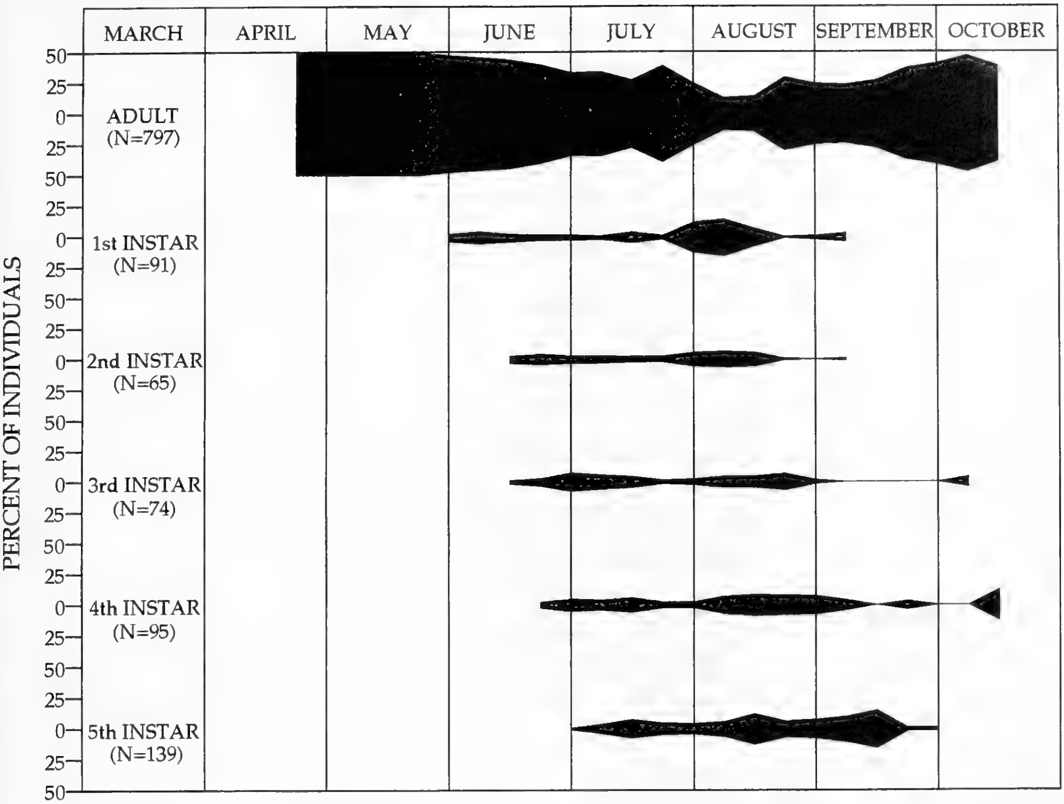


Fig. 2. Field cycle of *Oedancala dorsalis*. Percent of individuals of each stage per sample during 1995 season in Union Co., IL.

± 0.35 days, N = 125) and females (36.89 ± 0.32 days, N = 122) (Student's t-test = −0.9429, df = 245, p = .3467).

Mortality during the nymphal stadia resulted from incomplete ecdysis and unnatural causes (e. g., drowning in water condensation inside the dishes).

Precopulatory behavior was observed between three pairs of males and females and lasted 5–10 minutes. In two of the encounters, the first contact was head-to-head with both individuals touching antennae in a slow, irregular, up-and-down motion. Subsequently, the male moved around to the side of the female while antennating her, continued until he was behind her, and then mounted her from the side and extended his genitalia downward until engaged. In one of the two pairings, the male tapped the female with his legs during mounting. After 5 minutes, while still copulating and remaining attached, the male dismounted and rotated to about an 80° angle; shortly thereafter, the pair assumed a 180° end-to-end position. During copulation, the female moved about the petri dish, pulling the male. Copulation lasted approximately an hour. In the third encounter, the female initiated copulation. She antennated the male and crawled on and off his back repeatedly. The pair began copulating shortly thereafter. The male cleaned its rostrum and antennae during copulation. This pair remained in *copula* for approximately 25 minutes.

The six pairs of adults reproduced in the laboratory, with the females averaging 53.33 ± 13.37 eggs (range, 10–108).

The F_1 adults produced a second generation. In addition, fifth instars collected in

Table 1. Southern Illinois food plants of *Oedancala dorsalis*.

Host Taxon	Stages Collected[a]	Collection Site[b]
Cyperaceae		
Carex blanda Dewey	A	PH
C. cephalophora Muhlenberg	N, A	PH
C. comosa F. Boott	N, A	LC, PH
C. conjuncta F. Boott	A	OB
C. crinita Lamarck	N, A	LC, PH
C. crus-corvi Shuttleworth	A	PH
C. frankii Kunth	N, A	OB, PH
C. granularis Muhlenberg	A	PH
C. squarrosa L.	N, A	OB
C. tribuloides Wahlenberg	N, A	OB
C. vulpinoidea Michaux	N, A	OB, PH
C. vulpinoidea Michaux var. *ambigua* F. Boott (= *C. annectens* Bicknell)	N, A	OB, PH

[a] N = nymph; A = adult.

[b] LC = Lake on the Campus, Southern Illinois University; OB = Oakwood Bottoms; PH = La Rue-Pine Hills/Otter Pond Research Natural Area.

Table 2. Duration (in days) of each immature stage of *Oedancala dorsalis* under controlled laboratory conditions.

Stage	Number Completing Stadium	Range	$\bar{x}$ ± SE	Cumulative mean age
Egg[a]	621	10–16	13.32 ± .03	13.32
Nymph				
1st instar	533	3–10	6.34 ± .04	19.66
2nd instar	427	2–12	5.28 ± .09	24.94
3rd instar	307	1–15	4.52 ± .12	29.46
4th instar	263	2–11	4.02 ± .07	33.48
5th instar	247	2–8	5.52 ± .04	39.00

[a] 697 eggs were laid.

the field in late July and brought to the laboratory reached adults and subsequently reproduced. Both of these observations support our statement that *O. dorsalis* is bivoltine in southern Illinois.

Descriptions of immature stages.—*Egg* (Fig. 3A–B): Length, 1.41 ± 0.01; width, 0.34 ± 0.01. Eggs usually laid singly, sometimes in small clusters of 2–7; each elongate and whitish to pale green at oviposition, turning yellowish red during maturation. Chorion with longitudinal ridges; 3–7 micropylar processes in ring pattern at cephalic end.

Nymphal instars: The first instar is described in detail, but only major changes from previous instars are described for subsequent instars. Comparative statements (e.g., more punctate) refer to previous instars. The length is measured from tip of tylus to tip of abdomen and the width, across the widest part of the body. Additional measurements are given in Table 3.

First instar (Fig. 4): Length, 1.59 ± 0.02; width, 0.66 ± 0.01. Body generally yellowish orange in live specimens, paler in preserved ones. Sclerotized areas of head, thorax, abdomen, and legs dark brown. Head, thorax, and abdomen lightly setose; legs and antennae moderately setose. Body elongate, slightly pyriform, greatest width across abdominal segments 2–3.

Head narrowed in front, lateral margins tapering before antennae. Tylus exceeding juga, apex broad. Compound eyes red; pale line extending from inner margin of each eye posteromedially, meeting at midline of vertex, then extending to posterior margin of head. Antennae four segmented; segments 1 to 3 yellowish, segment 4 brown, segments white at incisures; segment 1 extending beyond apex of tylus; segment 4 acute apically; ratio of antennal segment lengths approximately 9:10:10:18. Rostrum four segmented, brown, extending onto abdominal segment 1.

Pro- and mesonota mostly sclerotized; sclerotized areas concolorous with head, in form of paired plates, plates separated medially. Pronotal plates subquadrate. Mesonotal plates subrectangular, posterior margins generally straight, laterally bending posteriorly, plates approximately 0.4× length of pronotal plates at midline. Metanotum more membranous; paired sclerites present, each subelliptical, approximately 0.7× length of mesonotal plates at midline. Thoracic pleura sclerotized, concolorous with corresponding notal plates; spiracles present on posterior margins of pro- and

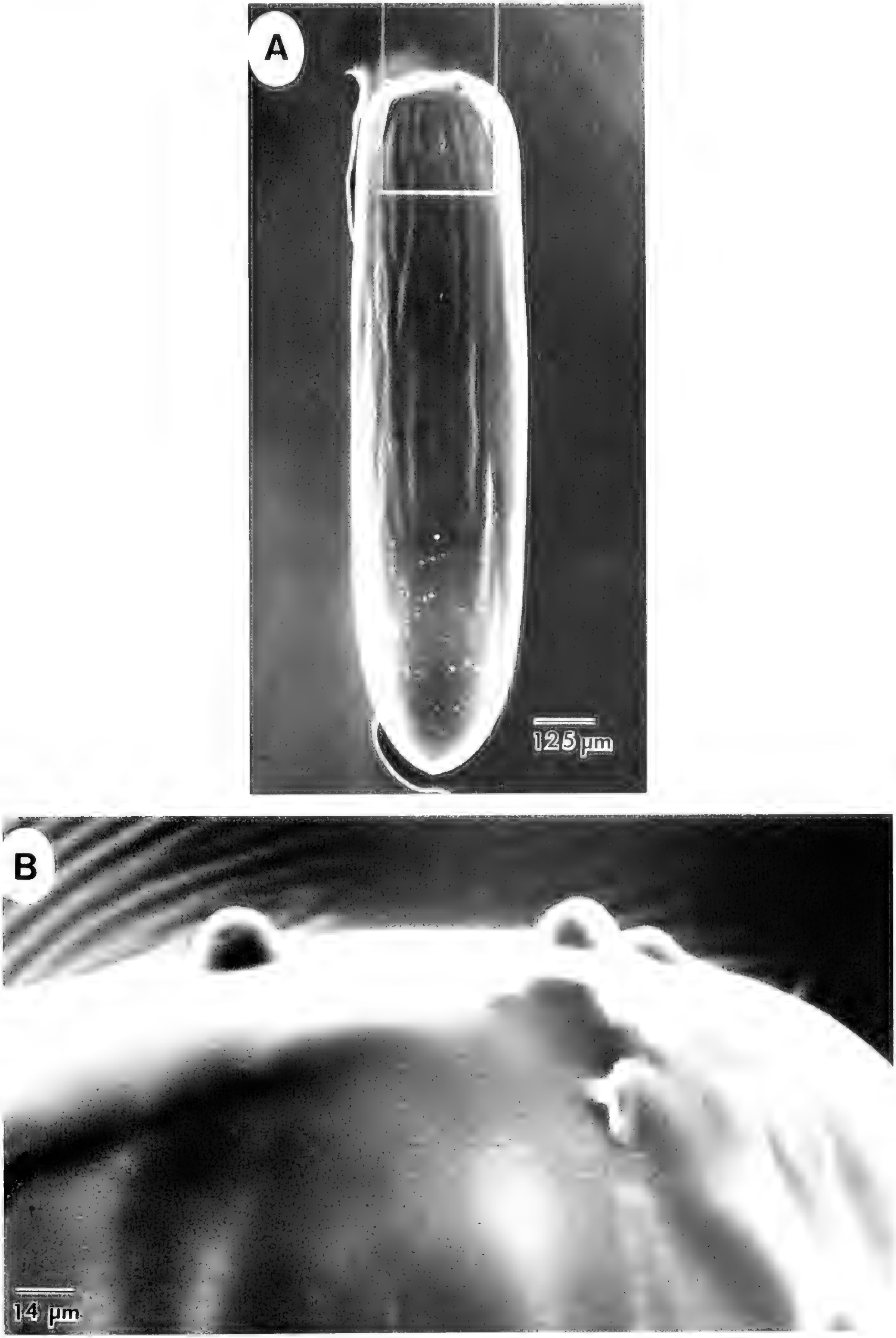


Fig. 3. Scanning electron micrographs of egg of *Oedancala dorsalis*. A, Egg. B, Micropylar region.

Table 3. Measurements (mm)[a] of *Oedancala dorsalis* instars.[b]

	Nymph				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Body length[c]	1.59 ± 0.02	2.02 ± 0.03	2.66 ± 0.05	3.81 ± 0.06	5.26 ± 0.08
Antennal segs.					
1st	0.18 ± 0.00	0.22 ± 0.00	0.32 ± 0.01	0.49 ± 0.01	0.75 ± 0.01
2nd	0.20 ± 0.00	0.26 ± 0.00	0.34 ± 0.00	0.45 ± 0.01	0.61 ± 0.01
3rd	0.20 ± 0.00	0.25 ± 0.00	0.34 ± 0.00	0.44 ± 0.00	0.59 ± 0.01
4th	0.37 ± 0.00	0.41 ± 0.00	0.50 ± 0.01	0.61 ± 0.01	0.74 ± 0.01
Head width at eyes	0.43 ± 0.00	0.57 ± 0.01	0.73 ± 0.01	0.93 ± 0.01	1.14 ± 0.01
Synthlipsis	0.32 ± 0.00	0.41 ± 0.01	0.52 ± 0.01	0.64 ± 0.01	0.75 ± 0.01
Head length[c]	0.30 ± 0.01	0.41 ± 0.01	0.50 ± 0.01	0.71 ± 0.02	0.86 ± 0.02
Beak segments					
1st	0.18 ± 0.00	0.25 ± 0.00	0.31 ± 0.00	0.40 ± 0.01	0.47 ± 0.01
2nd	0.23 ± 0.00	0.29 ± 0.00	0.35 ± 0.00	0.44 ± 0.01	0.52 ± 0.01
3rd	0.17 ± 0.00	0.23 ± 0.00	0.29 ± 0.00	0.39 ± 0.01	0.45 ± 0.01
4th	0.24 ± 0.00	0.28 ± 0.00	0.34 ± 0.00	0.40 ± 0.00	0.46 ± 0.00
Notal lengths[c]					
Pronotum	0.20 ± 0.01	0.29 ± 0.01	0.43 ± 0.01	0.69 ± 0.02	1.02 ± 0.01
Mesonotum	0.10 ± 0.00	0.17 ± 0.01	0.31 ± 0.01	0.59 ± 0.02	0.93 ± 0.02
Metanotum	0.10 ± 0.00	0.11 ± 0.00	0.10 ± 0.00	0.10 ± 0.00	0.11 ± 0.00
Notal widths					
Pronotum	0.49 ± 0.01	0.69 ± 0.01	0.96 ± 0.02	1.36 ± 0.03	1.81 ± 0.02
Mesonotum	0.53 ± 0.01	0.74 ± 0.02	1.04 ± 0.02	1.51 ± 0.03	2.16 ± 0.02
Metanotum	0.60 ± 0.01	0.80 ± 0.02	0.92 ± 0.02	1.00 ± 0.04	1.27 ± 0.06
Leg lengths					
Profemur	0.30 ± 0.01	0.40 ± 0.00	0.56 ± 0.01	0.85 ± 0.01	1.29 ± 0.01
Protibia	0.31 ± 0.01	0.41 ± 0.01	0.57 ± 0.01	0.80 ± 0.01	1.12 ± 0.01
Protarsus	0.22 ± 0.00	0.25 ± 0.00	0.33 ± 0.01	0.43 ± 0.01	0.57 ± 0.01
Mesofemur	0.29 ± 0.01	0.38 ± 0.01	0.50 ± 0.01	0.72 ± 0.01	1.01 ± 0.01
Mesotibia	0.30 ± 0.00	0.39 ± 0.00	0.54 ± 0.01	0.75 ± 0.01	1.01 ± 0.01
Mesotarsus	0.21 ± 0.00	0.25 ± 0.00	0.32 ± 0.01	0.42 ± 0.01	0.55 ± 0.01
Metafemur	0.34 ± 0.01	0.44 ± 0.01	0.61 ± 0.02	0.89 ± 0.01	1.27 ± 0.01
Metatibia	0.39 ± 0.01	0.51 ± 0.01	0.68 ± 0.01	0.97 ± 0.01	1.35 ± 0.02
Metatarsus	0.25 ± 0.01	0.29 ± 0.01	0.39 ± 0.01	0.49 ± 0.01	0.69 ± 0.01
Abd. width	0.66 ± 0.01	0.90 ± 0.02	1.22 ± 0.04	1.64 ± 0.03	1.95 ± 0.05

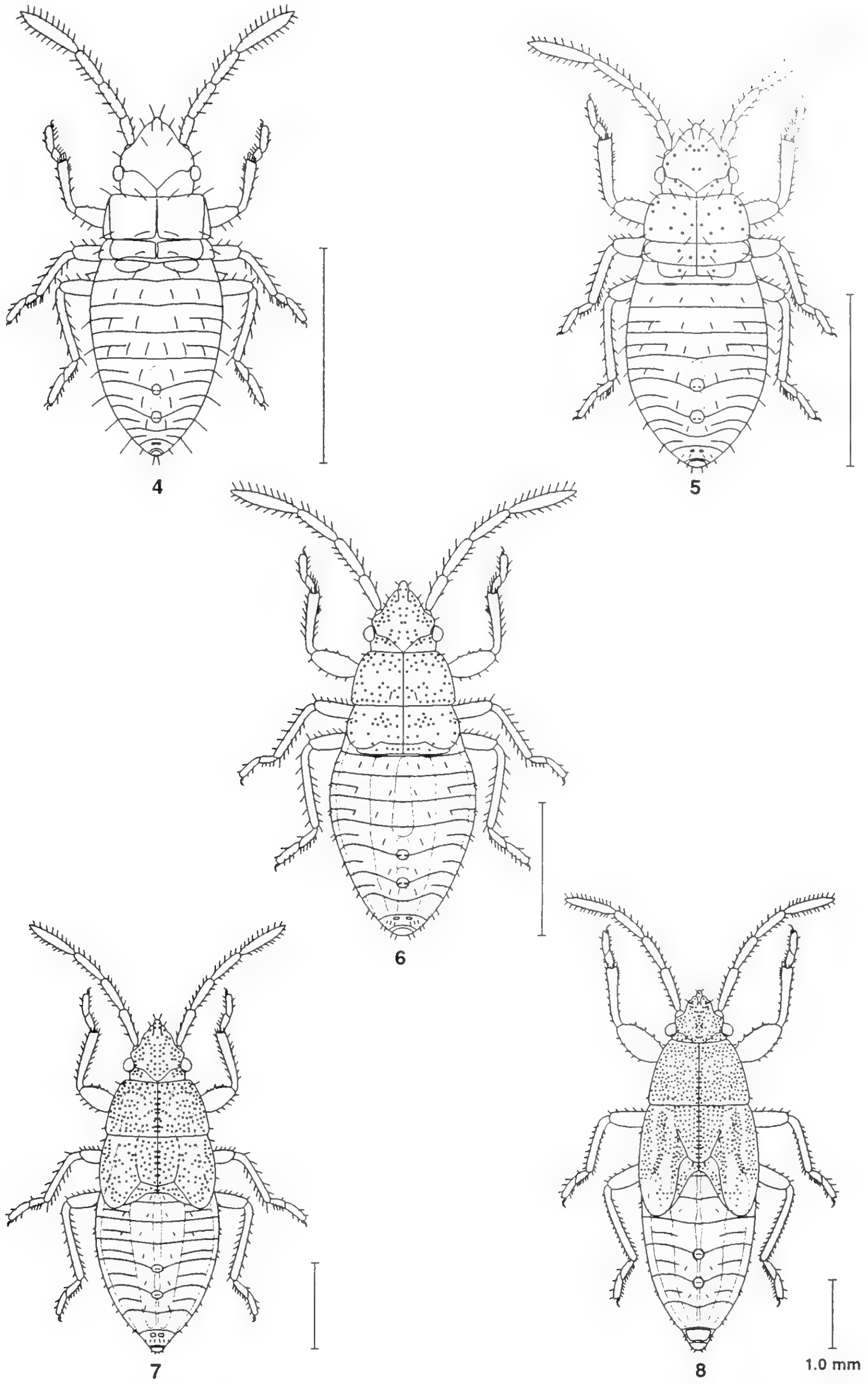
[a] $\bar{x}$ ± SE; values of <0.005 listed as 0.00.

[b] Based on 10 individuals of each instar.

[c] Measured at midline.

mesopleura. Thoracic sterna membranous, concolorous with membranous areas of nota. Coxae, trochanters, and femora generally brownish; tibiae brownish, yellowish apically; tarsi yellowish, last segment brownish in apical half; profemora slightly thickened, ventral margin usually with two small spines in distal half; tarsi two segmented.

Abdomen with paired scent glands medially on intersegmental lines between segments 4 and 5, and 5 and 6; each pair surrounded by circular, sclerotized plate; scent glands visible as median orange masses. Tergum 8 with pair of small, suboval sclerites medially; tergum 9 with posterior two thirds sclerotized; terga 1–6 each with sparse, transverse row of setae, 2–8 each



Figs. 4–8. Nymphal stages of *Oedancala dorsalis*. 4, First instar. 5, Second instar. 6, Third instar. 7, Fourth instar. 8, Fifth instar.

with single lateral seta, those of 5–7 longest; terga 2–7 each with faint pseudointersegmental line visible. Spiracles ventrolaterally on segments 2–8. Sterna 5–9 each with single medial plate, plates of variable shape; sterna 5 and 6 each with pair of small sublateral sclerites; sternum 7 with sublateral sclerite each side on posterior margin; setae generally more numerous than those on corresponding terga.

Second instar (Fig. 5): Length, 2.02 ± 0.03; width, 0.90 ± 0.02. Sclerotized areas of head and thorax sparsely and irregularly punctate.

Ratio of antennal segment lengths approximately 11:13:13:20.

Thorax with notal plates larger, fused medially, forming single plates; pale, median fusion line evident from near anterior margin of pronotum to posterior margin of metanotum. Pronotal plate covering pronotum. Mesonotal plate nearly covering mesonotum, subrectangular, posterior margin concave, approximately 0.5× length of pronotum at midline. Metanotum with plates fused; resulting plate subrectangular, covering approximately half of metanotum, approximately 0.3× length of mesonotum at midline. Paired, small, narrow, transverse sclerites on intersegmental line between metanotum and abdominal segment 1. Profemora thicker, ventral margin dentate in distal half with sparse row of teeth, distal two most prominent.

Abdomen, dorsally, sometimes with three poorly defined, reddish, longitudinal stripes, one medial and two lateral; segments 5–7 with lateral setae equal in length to those on remaining segments. Tergum 9 almost completely sclerotized.

Otherwise, similar to first instar.

Third instar (Fig. 6): Length, 2.66 ± 0.05; width, 1.22 ± 0.04. Sclerotized area of head and thorax more punctate.

Ratio of antennal segment lengths approximately 16:17:17:25.

Mesonotal plate larger, covering mesonotum, posterior margin concave medially, approximately 0.8× length of pronotum at midline; wing pads visible, small, not extending beyond posterior margin of metanotal plate. Metanotal plate larger, covering more than two thirds of metanotum, posterior margin straight, approximately 0.3× length of mesonotal plate at midline. Intersegmental sclerites between metanotum and abdominal segment 1 sometimes hidden by metanotum. Thoracic spiracles obscured by sclerotized pleura. Profemora thicker, teeth on ventral margin more prominent.

Abdomen with three stripes better defined; lateral setae often paired. Sterna 3–9 with medial sclerites, those on sterna 3–4 paired; intersegmental lines of sterna 1–5 occasionally with paired, transverse, linear, medial sclerites.

Otherwise, similar to second instar.

Fourth instar (Fig. 7): Length, 3.81 ± 0.06; width, 1.64 ± 0.03. Punctures more numerous. Body width usually greatest at abdominal segments 2–3.

Head with sclerotized areas generally yellowish to yellowish brown; dorsum with posterior margin dark brown to black. Pair of red ocelli sometimes visible, posterior and mesad to eyes. Ratio of antennal segment lengths approximately 10:9:9:12. Rostrum extending onto metasternum.

Thorax with sclerotized areas generally yellowish to brown; pleura with continuous, longitudinal, dark brown to black stripe, obscure to clearly defined. Pronotum usually with pair of longitudinal dark-brown to black stripes. Mesonotum with pair of stripes, concolorous and continuous with those of pronotum; mesonotum 0.9× length of pronotum at midline; wing pads longer, extending to abdominal tergum 2. Metanotal plate larger, completely covering metanotum, posterior margin arcuate; metanotum approximately 0.2× length of mesonotum at midline; wing pads evident laterally, extending to abdominal tergum 2, almost entirely covered by mesonotal wing pads. Meso- and metafemora and sometimes profemora more yellowish; profemora thicker, ventral margin dentate with three prominent subequal teeth distally, separated by smaller teeth.

Abdomen, dorsally, with three, reddish, longitudinal stripes now clearly defined; ventrally, with pair of diffuse, sublateral, reddish, longitudinal stripes. Tergum 8 with sclerites larger.

Otherwise, similar to third instar.

Fifth instar (Fig. 8). Length, 5.26 ± 0.08; width, 2.16 ± 0.02. Punctures more numerous. Body width usually greatest across mesothorax.

Head with sclerotized areas yellowish. Ocelli clearly visible. Antennal segment 1 brown on inner margin, remainder of segment yellowish; segment 2 yellowish; segment 3 yellow proximally, reddish brown to brown distally; segment 4 brownish; ratio of antennal segment lengths 5:4:4:5. Rostrum yellowish, extending onto posterior margin of mesosternum.

Thorax with sclerotized areas yellowish to yellowish brown; ventrally with pair of brown markings on meso- and metathoraces. Pronotum with stripes reduced, mesonotum with stripes still well defined; mesonotum 0.9× length of pronotum at midline; metanotum 0.1× length of mesonotum at midline; meso- and metanotal wing pads longer, extending onto abdominal tergum 3 or 4. Legs yellowish, ventral margin of profemora dark brown; profemora greatly swollen, ventral margin dentate with four prominent subequal teeth, separated by smaller teeth; tarsi apically, subacute dorsally.

Abdomen, ventrally, with two well-defined, longitudinal, sublateral red stripes; longitudinal red stripe present medially, varying from diffuse to well defined. Tergum 8 with paired sclerites fused to form plate almost entirely covering dorsal surface.

Otherwise, similar to fourth instar.

Diagnosis.—The five nymphal instars, in addition to size, can be separated readily by the relative lengths of the pro- and mesonota; sclerotization of the metanotum; relative lengths of the lateral abdominal setae; presence or absence of dorsal abdominal stripes; presence or absence, and degree of development, of wing pads; and presence or absence, and number and density, of punctures.

There is a progressive increase in the length of the mesonotum relative to the pronotum through all instars. The first instar can be separated from later instars by the lack of a single sclerotized plate on the metanotum, the relatively longer lengths of the lateral setae on abdominal terga 5–7, lack of punctures, and lack of dorsal abdominal stripes. The second instar can be distinguished from later instars by the lack of distinct mesonotal wing pads; wing pad development becomes apparent in the third instar with progressive development in the subsequent instars. The third-fifth instars can be distinguished from each other by the length of the mesonotal wing pads, which reach the metanotum in the third instar, abdominal tergum 2 in the fourth, and abdominal tergum 3 or 4 in the fifth. Finally, there is a progressive increase in the number and density of punctures in the second-fifth instars.

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TWO NEW GENERA AND THREE NEW SPECIES OF EUPLECTRINI (HYMENOPTERA: EULOPHIDAE) FROM THE NEW WORLD

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Abstract.—Two new genera (***Alveoplectrus***, type species *A. floridanus* W. & S. and ***Eurycephaloplectrus***, type species *E. columbianus* W. & S.) and three new species (***A. floridanus, A. truncatus***, and ***E. columbianus***) of the tribe Euplectrini (Hymenoptera: Eulophidae) are described. *Euplectrus corumbae* Ashmead is reclassified *Alveoplectrus corumbae* (Ashmead) **comb. n.** *Alveoplectrus floridanus* is a parasite of the larvae of *Alarodia slossoniae* (Lepidoptera: Limacodidae). *Eurycephaloplectrus colombianus* is parasitic on larvae of *Sibine* sp. (Lepidoptera: Limacodidae). The two genera are closely related and share some synapomorphies with the mainly Old World genus *Platyplectrus*.

Key Words: Chalcidoidea, Eulophidae, New World, *Alveoplectrus, Eurycephaloplectrus, Alarodia, Sibine*, parasites, Limacodidae

The tribe Euplectrini is unique within Eulophinae being the only cocoon weaving ectoparasites. Species in Euplectrini are united by the possession of an elongate hind tibial spur. This character has been observed to be somewhat variable. For example, the euplectrine genus *Metaplectrus* Ferrière has a relatively short hind tibial spur, and it appears very similar to the genus *Euplectrophelinus* Girault (J. LaSalle personal communication), which is not placed in the Euplectrini. In the absence of a thorough phylogenetic analysis of all the included genera, we continue to define Euplectrini based on this tibial spur character. Members of the tribe are distributed mainly in the Old World tropics, although species of *Euplectrus* Westwood are found worldwide. The tribe consists of six genera of which only two, *Euplectrus* and *Platyplectrus* Ferrière, are known to occur in the New World (Bouček 1988). The tribe is represented in North America by 13 species of *Euplectrus* (Burks 1979) and a single species of *Platyplectrus* (Schauff and LaSalle 1993). In our study on Sri Lankan Euplectrini we reported specimens of *Euplectromorpha* Girault from the New World (Wijesekara and Schauff 1994). Although these specimens possess two submedian carinae on the propodeum, the defining characteristic of *Euplectromorpha,* further analysis led us to conclude that these species are not properly placed in *Euplectromorpha.* In this paper, we erect two new genera for these species.

Museum abbreviations are as follows: National Museum of Natural History, Washington, D.C. (USNM); The Natural History Museum, London (BMNH). Terminology for surface sculpture follows Harris (1979).

Bouček (1988) produced a key to the genera of Euplectrini. His key is modified to include our new genera. *Awara* Bouček (1988) is not included in this key as it does not properly belong in the Euplectrini (Z. Bouček and J. LaSalle, in litt.).

KEY TO THE WORLD GENERA OF EUPLECTRINI

1. Propodeum with single median carina posterior to basal cup (Fig. 13) 2
– Propodeum with two submedian carinae; median carina lacking (Figs. 2, 6, 12, 14) 5
2. Scutellum without sublateral groove (as in Fig. 10); pronotum with transverse carina . . . . *Euplectrus* Westwood
– Scutellum with distinct sublateral groove (Figs. 5, 13, 14); pronotum variable 3
3. Hind tibia with a single, relatively short, apical spur; hind basitarsus subequal in length to second tarsomere . . . . *Metaplectrus* Ferrière
– Hind tibia with 2 distinctly elongate apical spurs; hind basitarsus much longer than second tarsomere 4
4. Submedian area of propodeum divided into more than four areolae; first tergum as long as half the length of metasoma . . . *Aroplectrus* Lin
– Propodeum with undivided submedian area; first tergum of metasoma variable . . . . *Platyplectrus* Ferrière
5. Scutellum without sublateral groove (Fig. 10); head relatively broad, more than 1.6× wider than high; petiole distinct, plate-like in dorsal view (Fig. 12) . . . . *Eurycephaloplectrus*, new genus
– Scutellum with distinct sublateral groove (Fig. 5); head less than 1.5× wider than high; petiole transverse, not visible dorsally 6
6. Scutellum with sublateral groove broad, contiguous with the posterior margin (Fig. 5); hind tibia with a single elongate spur (Fig. 7); hind tibial apex projected beyond point of attachment of basitarsus (Fig. 7); head with distinct tentorial depression lateral to clypeus (Fig. 4); postoccipital carina present (Fig. 1); species predominantly brownish in color . . . . *Alveoplectrus*, new genus
– Scutellum with sublateral groove narrow, not contiguous with the posterior margin (Fig. 14); hind tibia with one or two spurs; hind tibial apex not extended beyond point of tarsal attachment; head without facial depressions adjacent to clypeus; species including their appendages yellowish in color . . . . *Euplectromorpha* Girault

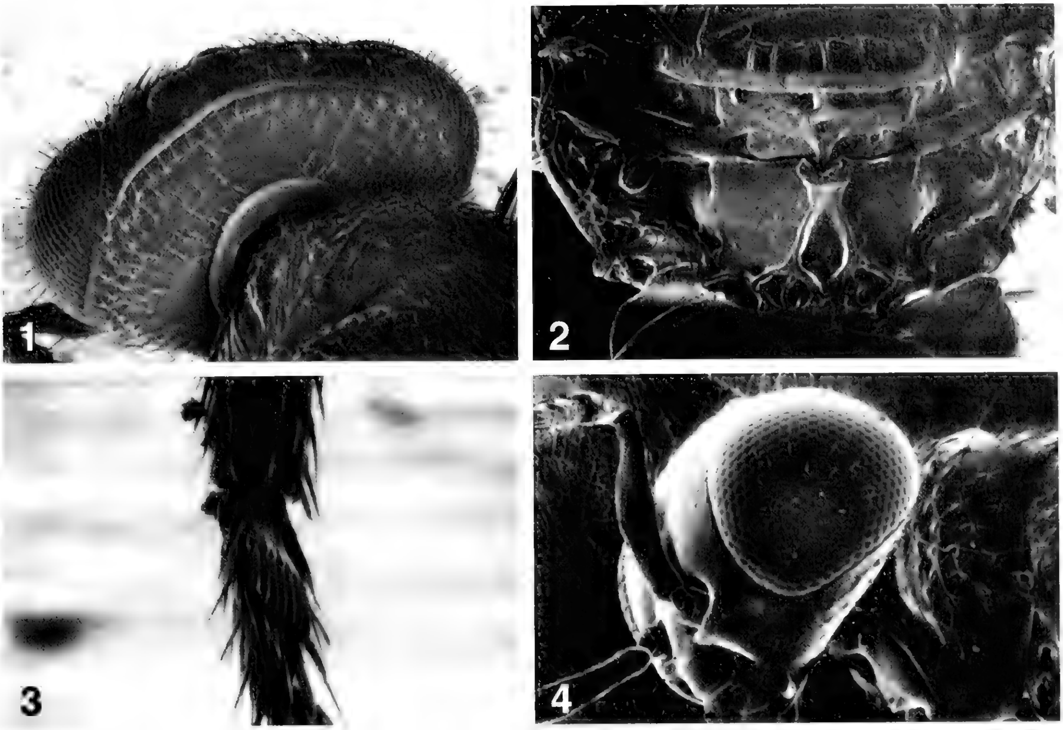
Alveoplectrus Wijesekara and Schauff, new genus

(Figs. 1–8, 15, 16)

Type Species: *Alveoplectrus floridanus* Wijesekara and Schauff.

Diagnosis.—Female with distinct tentorial depression on face near lateral margin of clypeus (Fig. 4); postoccipital carina present (Fig. 1); forebasitarsus with distinct strigil (Fig. 3); scutellum with sublateral groves which continue along the posterior margin (Fig. 5); mesepimeron with a distinct pit located closer to the posterior margin; dorsellum with posteriorly directed cup-like carina (Fig. 6); propodeum with two sublateral carinae that diverge posteriorly as a narrow triangle originating from basal cup (Figs. 2, 6); hind leg with single tibial spur which is as long as first two tarsomeres together; hind tibial margin extended beyond tarsal attachment point (Fig. 7).

Description.—Female. Compound eye with numerous long silvery setae; malar suture present; clypeus distinct but not demarcated by supraclypeal suture (Fig. 4); face convex; postoccipital carina present; POL 1.5× longer than OOL; frons and vertex uniformly covered with setae; occipital area flat compared to concave occiput of *Platyplectrus*, with scattered setae; mandibles reduced, not meeting medially and without teeth; first funicular segment and clava distinctly longer than other segment (Figs. 15, 16); scape not reaching level of anterior ocellus; pronotum uniformly covered with setae, without transverse carina; mesoscutum similarly covered with setae; axilla smooth, without setae; sublateral scutellar grooves contiguous along posterior margin of scutellum; mesepimeron with a distinct pit close to posterior mesopleural margin (Fig. 8); dorsellum medially with carina in form of posteriorly directed cup (Fig. 6); propodeum with two submedian carinae (Figs. 2, 6); petiole transverse; metasoma longer than broad, first tergum covering more than half length of metasoma;

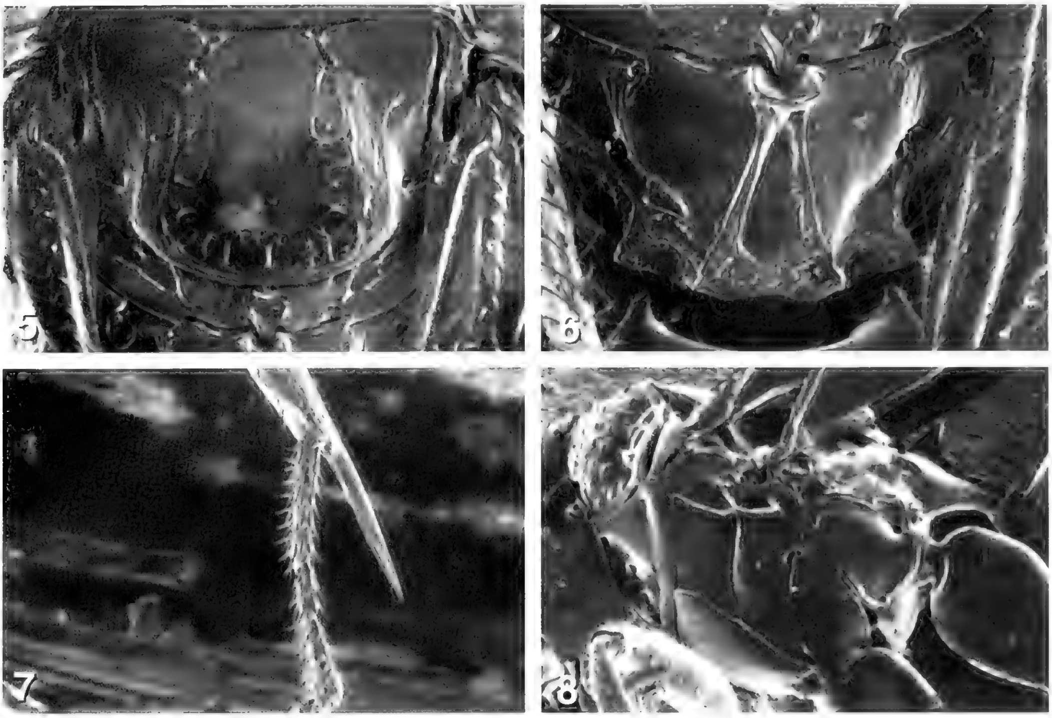


Figs. 1–4. 1–3, *Alveoplectrus floridanus*. 1, Head, posterior view. 2, Dorsellum and propodeum. 3, Strigil. 4, *A. truncatus*, head.

forebasitarsus with distinct strigil (Fig. 3); hind tibia with a single elongate spur; apical margin of hind tibia elongate beyond point of tarsal attachment (Fig. 7); hind basitarsus longer than following tarsomeres.

Discussion.—This genus can be distinguished from *Euplectromorpha* and *Platyplectrus* by the presence of the anterior tentorial depression, extended hind tibial margin, and cuplike median carina of the dorsellum. In both *Euplectromorpha* and *Platyplectrus* the dorsellum does not possess a cup-like carina, being either smooth in most species or irregularly carinated (few *Platyplectrus*), and their hind tibial margin does not extend beyond tarsal attachment point. The clypeal area is smooth with no demarcations or depressions in *Euplectromorpha*, whereas in *Platyplectrus* distinct supraclypeal carinae demarcate the clypeus, and there is no distinct depression near the tentorial pits.

The single hind tibial spur in *Alveoplectrus* is very distinct. Bouček (1988) considered the presence of a single tibial spur as a good generic character to identify *Metaplectrus* but we have observed some variation among other species. For example, *Euplectromorpha jamburaliyaensis* has a single hind tibial spur, although most *Euplectromorpha* species have two hind tibial spurs (Wijesekara and Schauff 1994). Based on this, we treat this character as homoplasious within the tribe. The presence of two submedian carinae on the propodeum has been regarded as autapomorphic for *Euplectromorpha* but is also characteristic of the two new genera. *Euplectromorpha* differs from *Alveoplectrus* by having fine lateral furrows on the scutellum



Figs. 5–8. *Alveoplectrus truncatus*. 5, Scutellum. 6, Dorsellum and propodeum. 7, Hindtibial spur. 8, Mesepimeron.

which are not posteriorly contiguous, and lacking postoccipital and pronotal carinae and posterior pit of the mesepimeron.

In all three species of *Alveoplectrus* the occipital carina is very distinctly developed as in some *Platyplectrus*, but we consider this character to be variable, as we also have examined single specimens of three additional undescribed species of *Alveoplectrus* from Central and South America, two of which do not possess the occipital carina.

The relationship of *Alveoplectrus* to other Euplectrini is difficult to assess. Overall, species of *Alveoplectrus* appear similar to those of *Platyplectrus*, and the posteriorly contiguous lateral carina on the scutellum, setaceous head, pronotum and mesonotum, and distinct strigil suggest a close relationship with that genus. In addition presence of a distinct pit on the mesepimeron closer to the posterior margin of the mesopleuron also suggest a closer relationship to *Platyplectrus*. Sharing of similar propodeal carinae by *Alveoplectrus* and *Euplectromorpha* is probably homoplasious.

Etymology.—"Alveo" comes from Latin "alveus" meaning cavity, and refers to the depressions on the face of species in the genus.

Key to the Species of *Alveoplectrus*

1. Mesepimeron divided by transverse sulcus (Fig. 8); frons below anterior ocellus without a transverse carinae 2
– Mesepimeron not divided by a sulcus; frons below anterior ocellus with short transverse carinae . . . . *corumbae* (Ashmead)
2. Antennal clava truncated; distal 3 flagellomeres distinct from others being whitish; occipital carinae without a lamina; posterior end of propodeum lacks alveole . . *truncatus*, new species
– Antennal clava slightly asymetrical, not distinctly truncated; all flagellomeres same color; occipital carinae with a lamina; posterior end of propodeum with lateral alveoli . . . . *floridanus*, new species

Alveoplectrus floridanus Wijesekara and Schauff, new species
(Figs. 1–3, 15)

Female.—Length 1.2–2.0 mm. *Color:* Head and mesosoma dark honey brown, antenna, legs except hind coxa, petiole, and metasoma except small area along lateral margin of first tergum yellow; hind coxa, petiole, and posterior lateral area of first tergum brownish but lighter than head and mesosoma. *Head:* Width 1.2× height; interocellar distance 2.5× eye width; frons and vertex evenly covered with short white setae; occipital and postoccipital carinae present (Fig. 1); POL:OOL 5:3; antennal clava slightly asymmetric; single anellus present; first funicular segment 1.2× longer than remaining funicular segments, which are subequal in length (Fig. 15). *Mesosoma:* Pronotum rectangular, collarlike, uniformly setose; mesoscutum similarly covered with setae; scutellum sculpture asperous; scutellum longer than broad with distinct lateral furrows contiguous with posterior margin; axilla smooth; mesepimeron divided into lower and upper mesepimeron by transverse sulcus terminating as a pit close to posterior mesopleural margin; propodeum smooth with two posteriorly diverging submedian carinae joining posteriorly with two lateral alveoli (Fig. 2). *Metasoma:* Longer than broad, petiole transverse, not visible from dorsal side; first tergum covers more than half metasomal length. *Legs and wings:* Hind coxa smooth; hind basitarsus 2× longer than remaining tarsomeres; forewing with postmarginal vein longer than stigmal vein.

Male.–Unknown.

Host.–Larvae of *Alarodia slossoniae* (Lepidoptera: Limacodidae).

Distribution.–Florida, Monroe Co.

Types.–Holotype ♀ on point with data: Florida, Monroe Co., Crane Key, 16-IV-76. Coll. D. Simberloff, ex. larvae *Alarodia slossoniae* (USNM). Paratypes: same data as holotype. (2 ♀ USNM, 1 ♀ BMNH).

Etymology.–The species epithet refers to the type locality.

Alveoplectrus truncatus Wijesekara and Schauff, new species
(Figs. 4–8, 16)

Female.—Length 1.7–2.0 mm. *Color:* head and mesosoma dark honey brown to black; first three funicular segments, coxae, and metasoma except lateral part of first tergite brownish; scape, pedicel, and legs except coxae yellowish; apical part of mid and hind femora and tibiae honey colored; antennal clava, fourth funicular, dorsal and ventral surface of first metasomal tergum whitish. *Head:* Width 1.2 × height; interocular distance 2× eye width; occipital and postoccipital carinae present; POL:OOL 7:4; first funicular segment 1.5× longer than second funicular segment; funicular segments becoming shorter and broader toward apex of antenna; clava about 1.6× longer than the preceding segment and distinctly truncated (Fig. 16). *Mesosoma:* Pronotum rectangular and covered with short brownish setae; mesonotum also covered with similar setae; scutellum and axilla smooth (Fig. 5); mesepisternum and mesepimeron smooth, mesepimeron divided into lower and upper mesepimeron by a transverse sulcus, which terminates as a pit close to posterior mesopleural margin (Fig. 8); propodeum with diverging submedian carinae enclosing a coarse raised median area, otherwise smooth (Fig. 6); posterior margin of propodeum without lateral carinae forming posterior alveole. *Metasoma:* First tergum extending over half of the metasoma. *Legs and wings:* Hind coxa smooth; single elongate hind tibial spur as long as first two tarsal segments together; hind basitarsus 2× longer than second tarsomere; postmarginal vein longer than stigmal vein.

Male.—Unknown.

Hosts.—Unknown.

Distribution.—Costa Rica.

Types.—Holotype ♀ on point with data: Costa Rica, Puntarenas, Golfo Dulce 3 Km.

W. Piedras Blancas, 100m. 3-V-1989 coll. Hanson (BMNH). Paratypes: same data as holotype (1 ♀ USNM); Costa Rica, Puntarenas, Gulfo Dulce 3 Km. S. Rincon, 10m. 2-III-1989. coll Hanson (2 ♀) Costa Rica, Heredia, Chilamate 75m. XII-1989, III-1990, Hanson and Godoy (1 ♀), (BMNH).

Etymology.—The species epithet refers to the truncated clava of the antenna.

Alveoplectrus corumbae (Ashmead), **new combination**

Euplectrus corumbae Ashmead, 1904: 517. Holotype ♀: Brazil, Corumba, H. H. Smith (USNM 60572).

Female diagnosis.—Head, mesosoma, and metasoma excluding the dorsum of the first tergum honey brown; legs yellow; antennal clava, third and fourth funicular segments brownish with a short transverse carinae just below anterior ocellus; posterior margin of dorsal axiller surface with distinct projection over scutoscutellar suture toward scutellum; basal cup of the propodeum enlarged, with a laminated margin; mesepimeron not divided into two parts by a sulcus.

Discussion.—*Alveoplectrus corumbae* can be easily distinguished from the *Alveoplectrus* species described above by the presence of distinct projections of the posterior margin of axilla (straight in *A. floridanus* and without any projection in *A. truncatus*), reticulate sculpture of the scutellum (smooth and asprous in *A. floridanus* and *A. truncatus*) and lack of a sulcus on mesepimeron dividing it into two parts (divided into upper and lower mesepimeron by a sulcus in both *A. floridanus* and *A. truncatus* (Fig. 8)).

Alveoplectrus corumbae was described by Ashmead (1904) from a single female specimen (USNM type no. 60572, examined). Vidal Sarmiento and DeSantis (1979) described a male of *A. corumbae* reared from *Spodoptera frugiperda* (J. E. Smith) (Noctuidae) as "allotype".

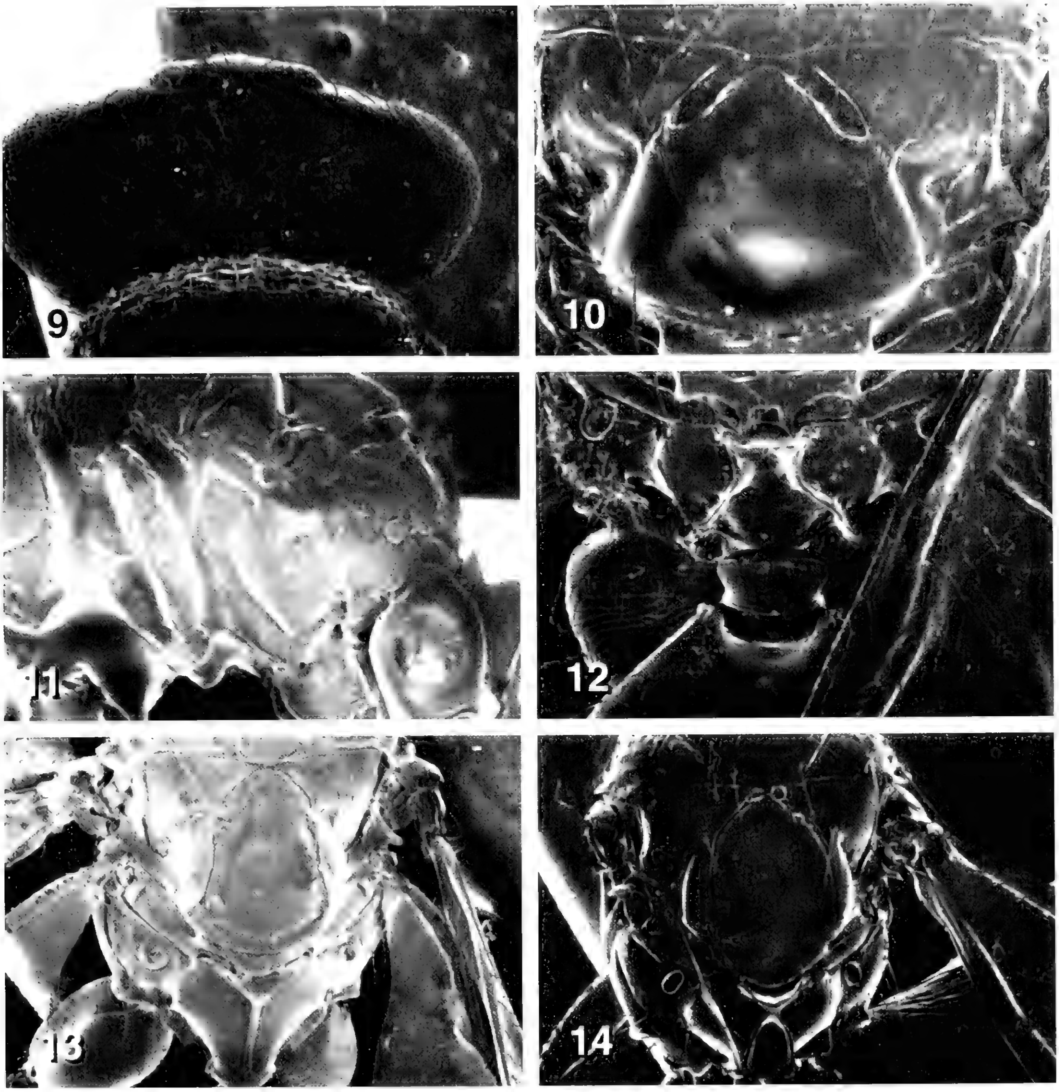
***Eurycephaloplectrus* Wijesekara and Schauff, new genus**
(Figs. 9–12)

Type species: *Eurycephaloplectrus colombianus* Wijesekara and Schauff.

Diagnosis.—Female head distinctly broader than high; occiput concave; head, pronotum and mesoscutum uniformly setose; scutellum smooth without lateral furrows and with two anteriorly contiguous distinct alveoli separating scutellum from axillae (Fig. 10); propodeum with posteriorly diverging submedian carinae which originate from basal cup separately; median carina absent (Fig. 12); petiole wider than long and distinctly visible dorsally, dorsal surface smooth and expanded like a plate (Fig. 12); abdomen shorter than mesosoma.

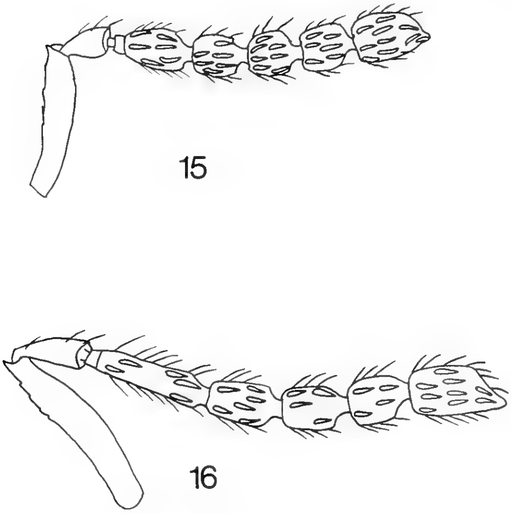
Description.—Female. Head more than 1.6× as broad as high; vertex and occiput uniformly covered with short setae; eye densely ciliated; malar sulcus distinct; clypeus not differentiated; occipital area concave; antennal scrobe distinctly marked; scape not reaching level of anterior ocellus. Pronotum and mesoscutum uniformly covered with short setae; axilla and scutellum smooth; distinct alveoli between scutellum and axilla; scutellum without lateral furrow; each axilla with two pairs of short setae (Fig. 10); mesepimeron with distinct pit near posterior margin (Fig. 11); dorsellum smooth; propodeum with two posteriorly diverging submedian carinae, which reach posterior margin of propodeum between abdomen and coxal foramina, closer to plica, making broader angle near basal cup when compared to *Alveoplectrus* (Fig. 12); petiole broader than long, platelike, and visible in dorsal view; metasoma shorter than mesosoma; strigil of fore basitarsus not distinct; hind tibia with two elongate spurs.

Discussion.—*Eurycephaloplectrus* is closely related to *Alveoplectrus*. The synapomorphies for this relationship are 1) uniformly ciliated head, pronotum, and mesonotum and 2) basally separated submedian



Figs. 9–14. 9–12. *Eurycephaloplectrus colombianus*. 9, Head, posterior view. 10, Scutellum. 11, Mesepimeron. 12, Dorsellum, propodeum, and petiole. 13, *Platyplectrus* sp., dorsum. 14, *Euplectromorpha* sp., dorsum.

carina on the propodeum. The distinct pit close to the posterior margin of the mesepimeron is similar to the state found in *Platyplectrus* and is considered homologous to the similar structure in *Alveoplectrus*. However this genus differs from *Alveoplectrus* in lack of sublateral scutellar furrows, absence of a distinct depression on the face lateral to clypeus; lack of an elongate strigil; presence of two pairs of setae on each axilla; presence of a dorsally expanded petiole; and presence of two hind tibial spurs. Species of *Alveoplectrus* possess distinct depressions lateral to the clypeus, posteriorly contiguous sublateral furrows on the scutellum, distinct strigil, no setae on axilla, transverse petiole, and a single hind tibial spur. *Eurycephaloplectrus* is



Figs. 15–16. Female antenna. 15, *Alveoplectrus floridanus*. 16, *A. truncatus*.

similar to *Euplectrus* in lacking lateral furrows on the scutellum but differs from it by having a distinct malar suture and lacking a median carina on the propodeum.

Etymology.—"Eurys" meaning broad and "cephalo" meaning head (both Greek) together refer to distinctly broad head of this genus, and is combined with the stem "plectrus".

Eurycephaloplectrus colombianus **Wijesekara and Schauff, new species**

(Figs. 9–12)

Female.—Length: 1.4–1.5 mm. *Color:* Head, ventral and lateral mesosoma, hind coxa, and petiole honey brown; mesosoma dorsally much darker than head, almost black; metasoma except anterior dorsal area, fore and hind coxae and hind femur light brown; antennae, legs except all coxae and hind femur and anterior dorsal area of metasoma yellow. *Head:* Width 1.6× height; interocular distance 2.5× eye width; mouth margin broad; antennal scrobe distinctly depressed; vertex and occipital area uniformly covered with setae; eye densely setose; occipital and postoccipital carina absent (Fig. 9); POL:OOL 9:7; occiput concave; first funicular segment 1.2× longer than second funicular segment; funicular segments 2–4 subequal in length; clava distinctly longer than funicular segments. *Mesosoma:* Pronotum collarlike and uniformly setose (Fig. 9); mesoscutum covered with similar white setae; mesepimeron not divided (Fig. 11); dorsellum and propodeum smooth; basal cup distinctly developed; two submedian carinae originate separately from basal cup and diverge posteriorly; propodeal margin laterally with few white setae (Fig. 12). *Metasoma:* Petiole smooth, broader than long; dorsal surface of petiole distinctly expanded and plate-like; metasoma distinctly shorter than mesosoma. *Legs and wings:* hind tibia with two elongate spurs; hind basitarsus slightly longer than other tarsomeres; wings at rest extended beyond apex of metasoma; postmarginal vein longer than stigmal vein.

Male.—Unknown.

Host.—Larvae of *Sibine* sp. (Lepidoptera: Limacodidae).

Distribution.—Colombia, Tibaitata.

Types.—Holotype ♀ on point with data: Colombia, Tibityata, 21-VIII-1974, Coll. J.A. Jimenez, "Acacias vet" ex. *Sibine* larvae (USNM). Paratypes; 3 females with same data as holotype (2 ♀ USNM, 1 ♀ BMNH).

Etymology.—The species epithet refers to the type locality.

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A NEW SPECIES OF GALL MIDGE (DIPTERA: CECIDOMYIIDAE) FROM ECUADOR ASSOCIATED WITH FLOWERS OF *CLAVIJA* (THEOPHRASTACEAE)

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Abstract.—A gall midge new to science, ***Charidiplosis clavijica* Gagné**, is described from specimens found standing on male flowers of *Clavija weberbaueri* (Theophrastaceae) in eastern Ecuador. The new species is notable for several unique characters involving the tarsal claws, the male antenna, and the female ovipositor. The new species is compared to the widespread and only other described congener, *Charidiplosis triangularis* (Felt), a species associated with flowers of cacao.

Key Words: Neotropical, Charidiplosis, pollination

Clavija is a Neotropical plant genus of 50 species (Ståhl 1991). The pollination and breeding system of *Clavija* species have not been studied previously in the field. Two of us (CO, SSR) are investigating floral morphology in *Clavija* in an attempt to determine which species are androdioecious, as suggested by Ståhl (1991). The reproductive biology of *Clavija weberbaueri* Mez. was studied during two stays at the Jatun Sacha Biological Reserve in eastern Ecuador in September, 1994 and October, 1995. This plant is an understory shrub of about 0.8–1.5 m height, frequent along trails at Jatun Sacha. Flowers are orange, bowl shaped, ca. 1 cm diameter, and emit a fruity scent, especially at night. The chemical composition of the floral scents of *C. euerganea* Macbr. and *C. repanda* Ståhl have been investigated by Knudsen and Ståhl (1994). Scents in these two species are very similar and consist almost exclusively of sesquiterpenes. In both years when *C. weberbaueri* was studied at Jatun Sacha, numerous individuals were in bloom.

One of us (CO) monitored six shrubs with bisexual flowers and ten male shrubs from October until December in both years. The only visitors seen on the male flowers during several observation periods, both during the day and at night until 11 p.m., were gall midges of the new species described here. The flies remained immobile on the flowers for long periods of time, except at dusk when some individuals were observed to fly. Female flowering shrubs were extremely rare in both years, and we did not see any visitors on the few female flowers we found. Whether these gall midges pollinate the flowers is still unclear.

MATERIALS AND METHODS

The new species was collected by one of us (CO) in September, 1994 and October, 1995, at the Jatun Sacha Biological Reserve, Napo Province, Ecuador. The Reserve is located 8 km E of Puerto Misahualli on the eastern slope of the Andes at about 400 m elevation (01°04′S, 77°36′W). Mean annual precipitation at Jatun Sacha is 3600 mm and the average yearly temperature is about 24.5°C. Fresh-caught flies were killed and preserved in 70% ethanol and later slide mounted for scientific study using the method outlined in Gagné (1989, 1994). Specimens of the new species have been deposited in the Museo Ecuatoriano de Ciencias Naturales in Quito, Ecuador, and the National Museum of Natural History, Smithsonian Institution, (USNM) in Washington, DC, U.S.A. Terminology for adult morphology follows usage in McAlpine (1981).

***Charidiplosis clavijica* Gagné, new species**

(Figs. 1–7)

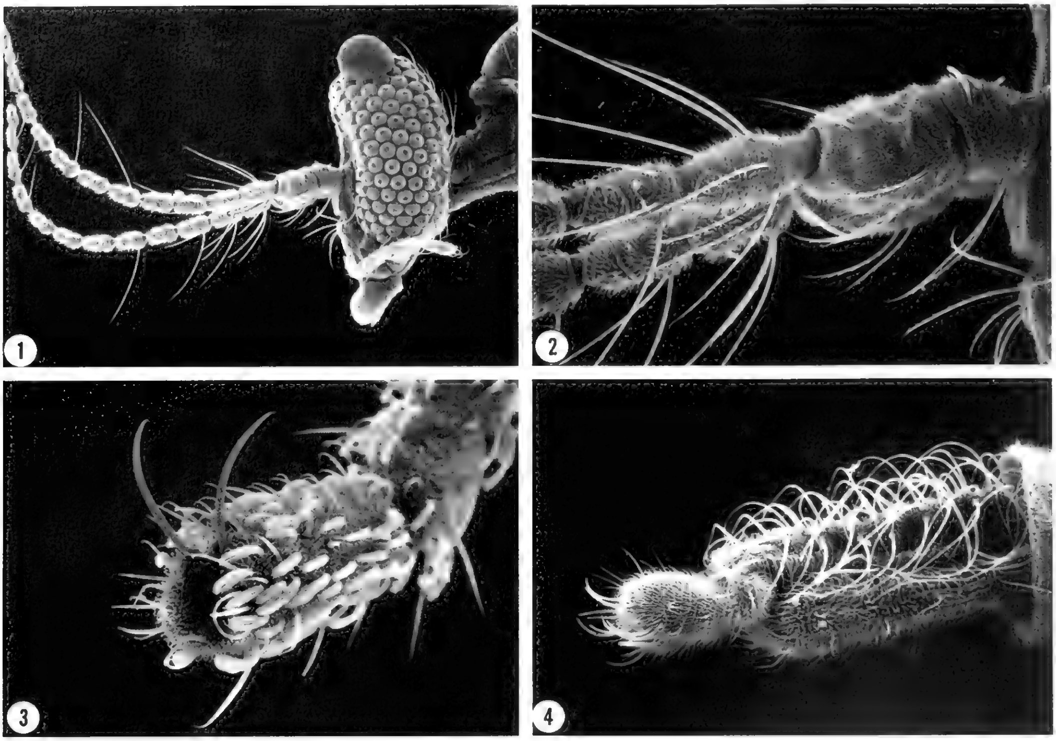
Adult.—Head (Figs. 1–2): Eye 9–10 facets long at vertex, connate; facets all closely adjacent. Vertex with narrow, dorsal protuberance bearing 2 long setae. Frons with 3–4 setae per side. Labella elongate linear in frontal view, more or less ovoid in lateral view, with about 15 setae laterally and covered with fine, pliant setulae mesally. Labrum elongate, basally with several short, sensory setae, covered beyond base on dorsum with long, fine, pliant, setulae, and situated between the labellae. Hypopharynx wide, striated dorsally and with elongate, setulose ligule ventrally. Palpus 4 segmented, with basal palpiger. Antenna with 12 flagellomeres, pedicel enlarged, longer and wider than both scape and first flagellomere. Male flagellomeres (Fig. 2) gynecoid, cylindrical, with very short necks, and becoming successively narrower from base to apex; circumfila appressed, as 2 rings encircling the flagellomeres, interconnected by 2 longitudinal strands. Female flagellomeres as in male but all of same width.

Thorax: Scutum with 4, single, sparse longitudinal rows of setae. Anepisternum without vestiture. Epimeron with 4–6 setae in longitudinal row. Wing length: ♂, 1.4–1.6 mm (n = 5); ♀, 1.5–1.6 mm (n = 4); R_5 curved apically, joining C posterior to wing apex; Rs weak, oblique, situated proximal to mid distance between arculus and R_1 apex; M_{3+4} evident on distal two-thirds length; Cu forked; CuP present before Cu fork. Fifth tarsomeres (Figs. 3, 7) with acropod partly hidden from view; claws simple, thin, curving near basal third; empodia and pulvilli rudimentary.

Male abdomen: First through sixth tergites entire, rectangular, with mostly single, continuous, posterior row of setae, 1–3 lateral setae on each side near midlength, sparse setiform scales covering most of sclerites, and pair of trichoid sensilla on anterior margin. Seventh tergite as for sixth but posterior row of setae interrupted mesally. Eighth tergite weakly sclerotized, anterior pair of trichoid sensilla the only vestiture. Genitalia (Fig. 5–6): cercus narrowing to rounded apex, with several posterior setae; hypoproct slightly longer than cercus, tapered gradually from base to very narrow apex, a pair of setae present apically; aedeagus longer than gonocoxite, tapered evenly from base to narrow apex; gonocoxite with short, obtuse mesobasal lobe, cylindrical beyond; gonostylus elongate, cylindrical, barely tapered from base to apex, setulose near base, asetulose and ridged beyond.

Female abdomen: First through seventh tergites as for male first through sixth. Eighth tergite square, shorter and narrower than seventh, with scattered setae on posterior half and anterior pair of trichoid sensilla. Eighth sternite present, with scattered setae and anterior pair of trichoid sensilla. Intersegmental membrane with scattered setae on all surfaces. Ninth tergum (Fig. 4) dorsally with elongate, curved setae, laterally and ventrally with short, scattered setae. Tenth tergum without setae. Cercus (Fig. 4) elongate-ovoid, completely setulose, with four apical to apicoventral sensory setae; hypoproct elongate, undivided.

Pupa and larva.—Unknown.



Figs. 1–4. *Charidiplosis clavijica*. 1, Male head (lateral; spheroid mass on top of head is a contaminant). 2, Male scape, pedicel, and base of flagellum (lateral). 3, Apex of tarsus showing partially recessed claws. 4, Female ninth abdominal segment and cerci (lateral).

Holotype.—♂, on male flower of *Clavija weberbaueri*, 6-x-1995, Jatun Sacha, Ecuador, C. Ott, deposited in the Museo Ecuatoriano de Ciencias Naturales in Quito (MECN).

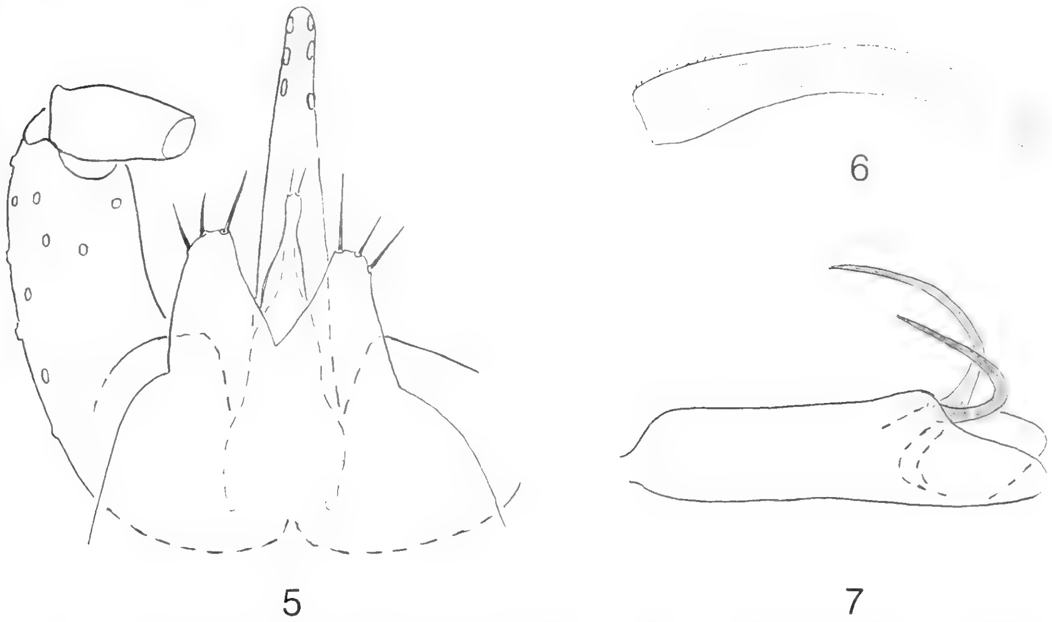
Other material.—10 ♂, 10 ♀, same data as holotype; 2 ♂, 2 ♀, same data as holotype except IX-1994; specimens deposited in MECN and USNM.

Etymology.—The name *clavijica* means "with *Clavija*."

Remarks on taxonomy.—The new species belongs in *Charidiplosis* because of its narrow, elongate male hypoproct in association with the long, tapering aedeagus, and, in the female, its setose eighth tergite and sternite and long ovipositor and cerci. The species will run to *Charidiplosis* in the key to Neotropical genera of Cecidomyiidi in Gagné (1994).

The only other described species of *Charidiplosis* is *C. triangularis* (Felt), a widespread species known from North and South America and reared from mushrooms and decaying organic matter, including cow manure. Larvae of the new species will presumably also be found feeding in decaying organic matter. Adults of *C. triangularis* have been taken repeatedly in cacao flowers in Costa Rica (Young 1985, as *Aphodiplosis triangularis*), although their role on those flowers is also unknown.

Charidiplosis clavijica differs from *C. triangularis* in several derived character states of the fifth tarsomere, the male antenna, and the setation of the ninth segment of the ovipositor. The acropods are largely hidden from view within the covering sides of the apex of the fifth tarsomeres, the tarsal claws are elongate and narrow, and the empodia and pulvilli are rudimentary (Figs. 3, 7). Because gall midges stand on the apices



Figs. 5–7. *Charidiplosis clavijica*. 5, Male genitalia (in part; dorsal). 6, Gonostylus (dorsal). 7, Fifth tarsomere and acropod.

of the tarsi, these derived characters may be adaptations for locomotion or for grasping a particular kind of surface. The male antenna (Figs. 1–2) is gynecoid and short, the pedicel is enlarged, and the flagellum becomes gradually narrower from base to apex. While unique in Cecidomyiinae, this antenna is reminiscent of that of the fast-flying and swarming Lestremiinae of the genera *Anarete* and *Conarete* and suggests the new species may have similar habits. Foreshortened antennae offer less resistance to the air than the several times longer male antennae of *C. triangularis* and most other male Cecidomyiidi. The setae of the female ninth tergum (Fig. 4) are unique for their long length, and the fact that they are curved evidently allows the ninth segment to be retracted readily. We suggest that the long setae function as additional surface area for female pheromones produced in the intersegmental region of the ovipositor and released when the ninth segment is exserted (Solinas and Isidoro 1991, Isidoro et al. 1992).

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FIVE NEW SPECIES AND A NEW RECORD OF COSTA RICAN *LEPTONEMA* GUÉRIN (TRICHOPTERA: HYDROPSYCHIDAE)

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Abstract.—Eighteen species of the genus *Leptonema* (Trichoptera: Hydropsychidae: Macronematinae) are reported from Costa Rica. In this paper, five additional undescribed species of *Leptonema* from Costa Rica are diagnosed, described and illustrated: ***L. clorito, L. flintorum, L. huismanae, L. rafita,*** and ***L. tapanti.*** Their distribution records in Costa Rica are mapped. Also, *L. cheesmanae* Mosely is illustrated and recorded from Costa Rica for the first time.

Resumen.—El género *Leptonema* (Trichoptera: Hydropsychidae: Macronematinae) presenta dieciocho especies en Costa Rica. En el presente manuscrito se ofrecen las diagnosis, descripciones e ilustraciones de cinco especies no descritas de *Leptonema* presentes en Costa Rica: ***L. clorito, L. flintorum, L. huismanae, L. rafita,*** y ***L. tapanti.*** Se trazan en el mapa los registros de distribución en Costa Rica de estas especies. Además, se informa y se trazan en el mapa los primeros registros de distribución en Costa Rica de *L. cheesmanae* Mosely, la cual también es ilustrada.

Key Words: *Leptonema*, Trichoptera, caddisfly, new species, Costa Rica, Neotropics, taxonomy

The genus *Leptonema* Guérin is one of the best known and most easily recognized of the Neotropical caddisflies. The adults are large (10–40 mm) with light brown to light green translucent wings. Some species have black spots or small areas of dark coloration on the forewings. In the New World, the genus is widely distributed from southern North America through Central and South America, including the islands of the Antilles (Flint et al. 1987). Species also occur in Africa and Madagascar.

The genus was established by Guérin (1843) for the Brazilian species *Leptonema pallidum*. In 1914, Banks reported *Leptonema albovirens* (Walker) from Costa Rica, the first record of the genus for Costa Rica. Mosely (1933) recorded two additional species from Costa Rica in his revision of the genus. Flint, McAlpine, and Ross (1987) provided an exhaustive taxonomic review of the world species, and also considered phylogenetic and biogeographic aspects. They described 48 new species, four of them from Costa Rica, and recorded five additional species from the country. Holzenthal (1988) added six additional species records. In total, eighteen species of *Leptonema* have been recorded in Costa Rica, (Table 1).

In addition to the described species, five undescribed species of *Leptonema* were found in collections made in Costa Rica from 1986 through 1992 by R. W. Holzen-

Table 1. List of *Leptonema* species and species groups, defined by Flint et al. (1987), recorded in Costa Rica, with distribution records as published by Flint et al. (1987) and Holzenthal (1988).

Species	Distribution
Crassum Group	
L. crassum Ulmer 1905	Mexico; Guatemala; Honduras; Nicaragua; Costa Rica: Alajuela, Guanacaste, Heredia, Limón; Panama; Colombia; Venezuela; Brazil; Peru; Paraguay; Argentina.
L. divaricatum Flint, McAlpine, Ross 1987	Costa Rica: Limón; Colombia; Venezuela; Ecuador.
Stigmosum Group	
L. tapanti, new species	Costa Rica: Cartago; Panama.
Plicatum Group	
L. ekisi Flint, McAlpine, Ross 1987	Costa Rica: Alajuela, Cartago; Panama.
L. flintorum, new species	Costa Rica: Puntarenas.
L. fortunum Flint, McAlpine, Ross 1987	Costa Rica; Panama.
L. hamuli Flint, McAlpine, Ross 1987	Costa Rica: Cartago; Panama.
L. huismanae, new species	Costa Rica: Alajuela, Guanacaste.
L. rafita, new species	Costa Rica: Alajuela, Cartago, San José.
L. salvini Mosely 1933	Costa Rica; Panama.
L. sinuatum Mosely 1933	Costa Rica; Panama; Colombia.
L. turrialbum Flint, McAlpine, Ross 1987	Costa Rica: Alajuela, Cartago.
L. vitum Flint, McAlpine, Ross 1987	Costa Rica: Puntarenas.
L. woldianum Flint, McAlpine, Ross 1987	Costa Rica; Panama.
Simulans Group	
L. asclepium Flint, McAlpine, Ross 1987	Costa Rica: Cartago, San José.
L. campanum Flint, McAlpine, Ross 1987	Costa Rica; Panama.
L. simulans simulans Flint, McAlpine, Ross 1987	Costa Rica: Alajuela, Cartago, Guanacaste, Puntarenas, San José; Panama.
Pallidum Group	
L. albovirens (Walker) 1852	USA: Texas; Mexico; Belice; Guatemala; Honduras; Nicaragua; Costa Rica; Panama; Colombia; Venezuela; Trinidad & Tobago; Granada; St. Vincent.
Complexum Group	
L. cheesmanae Mosely 1933, new record	Costa Rica: Alajuela, Guanacaste, Limón, San José; Panama; Colombia.
L. clorito, new species	Costa Rica: Alajuela.
L. complexum Mosely 1933	Costa Rica: Alajuela, Cartago, Limón; Panama.
L. forficulum Mosely 1933	Costa Rica; Panama.
L. furciligerum Flint, McAlpine, Ross 1987	Costa Rica: Puntarenas.
L. intermedium Mosely 1933	Costa Rica: Alajuela, Cartago, Heredia, San José; Panama; Colombia; Ecuador.

thal and his colleagues. In the present paper these species are diagnosed, described, and illustrated. Also, *L. cheesmanae* Mosely is illustrated and recorded from Costa Rica for the first time. Terminology used for genitalic structures follows that presented by Flint et al. (1987). This paper represents the results of an ongoing project, sponsored by the National Science Foundation and the University of Minnesota Insect Collection, to catalog and describe the caddisfly fauna of Costa Rica. Holotypes of the species described are deposited in the collections of the National Museum of Natural History, Smithsonian Institution, Washington, DC (NMNH). Paratypes and other specimens examined, are deposited in the collections of the University of Minnesota Insect Collection, St. Paul, Minnesota (UMSP), the National Museum of Natural History, Smithsonian Institution, Washington, DC (NMNH), and the Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica, (INBIO). All specimens are pinned unless otherwise noted.

Leptonema clorito **Muñoz-Q., new species**

(Fig. 1, Map 1)

Diagnosis.—This species belongs within the *complexum* Group, as defined by Flint et al. (1987). It is very similar to *Leptonema cheesmanae* Mosely, but can be distinguished from that species by the shape of process "*d*" of the phallic apparatus. In *L. clorito*, process "*d*" consists of only the apical arm, which is elongate, slender, directed dorsally at base, and curved apically, as viewed laterally. In *L. cheesmanae*, process "*d*" consists of both apical and basal arms. In lateral view, the apical arm is elongate, curved, and directed posteriorly, the basal arm is slender, long, and projected anteriorly beyond of the apex of process "*e*" and the base of process "*f*". Finally, in *L. clorito*, the lateral lobes of segment X are triangular, as viewed dorsally; these are subquadrate in *L. cheesmanae*.

Description.—*Male:* Length of forewing 17 mm. Body sclerites pale yellow. Dorsum of head pale yellow and with short, light brown setae. Legs with fine, yellowish setae. Wings light green, translucent; forewing covered with fine, short, yellowish setae, with small rounded patch of brownish setae over area around anterior angle of medial cell; apical third of forewing slightly infuscate. Maxillary palpus with fifth segment about 3/5 length of basal 4 segments combined. Process of sternum V large, oval. *Genitalia* (Fig. 1): Segment IX, as viewed laterally, narrow, elongate, with V-shaped dorsal keel. Segment X with wart "*a*" elongate, base narrow, apex bulbous; wart "*b-1*" elongate, fingerlike; wart "*b-2*" short; wart "*c*" absent; lateral lobes, as viewed dorsally, triangular, projecting posteriorly; as viewed laterally, lateral lobes rounded, bearing short setae on lateral margin; ventral margin of segment X with hooklike lobe. Inferior appendage two segmented, basal segment slightly more than 4 times length of apical segment, widest subapically; apical segment with short setae on inner margin. Phallus with midsection long, tubular; apical section complex, bearing two, tiny, sharply pointed, sclerotized phallotremal sclerites behind process "*a*", visible in dorsal view; process "*a*", as viewed laterally, fingerlike, apex truncate, elevated and arched over process "*g*" and phallotremal sclerites; as viewed dorsally, process "*a*" tonguelike, apex truncate, lightly sclerotized, arising dorsomesally; processes "*b-1*" and "*b-2*" short, sharply pointed, lightly sclerotized, arising apically, and directed anterodorsally; process "*c*" long, slender, arising subapically, apex pointed, directed anteriorly, and reaching base of process "*a*"; basal stalk of process "*d*", as viewed laterally, erect, directed dorsally; apical arm of process "*d*" curved apically, arising dorsomesally; as viewed dorsally, basal arm of process "*d*" absent; apical arm bifurcated basally, its projections pointed, projected posterolaterally; process "*e-1*", as viewed dorsally, spinelike, short, apex rounded, arising dorsolaterally and projecting posterolaterally; process "*e-2*", as viewed dorsally, bifurcated, arising dorsomesally, its projections long, slender, slightly serrated, arched, projecting anteriorly, with pointed apices reaching base of process "*f*"; process "*f*" fingerlike, elongate, arising dorsomesally, apex rounded, reaching base of apical arm of process "*d*"; process "*g*" a ventrolateral lobe, broad, flat, rounded; as viewed dorsally, emarginated, with mesal projection, apex rounded and projected posteriorly; process "*j*" absent.

Type material.—Holotype: ♂, COSTA RICA: *Alajuela:* Cerro Campana, ca. 6 km

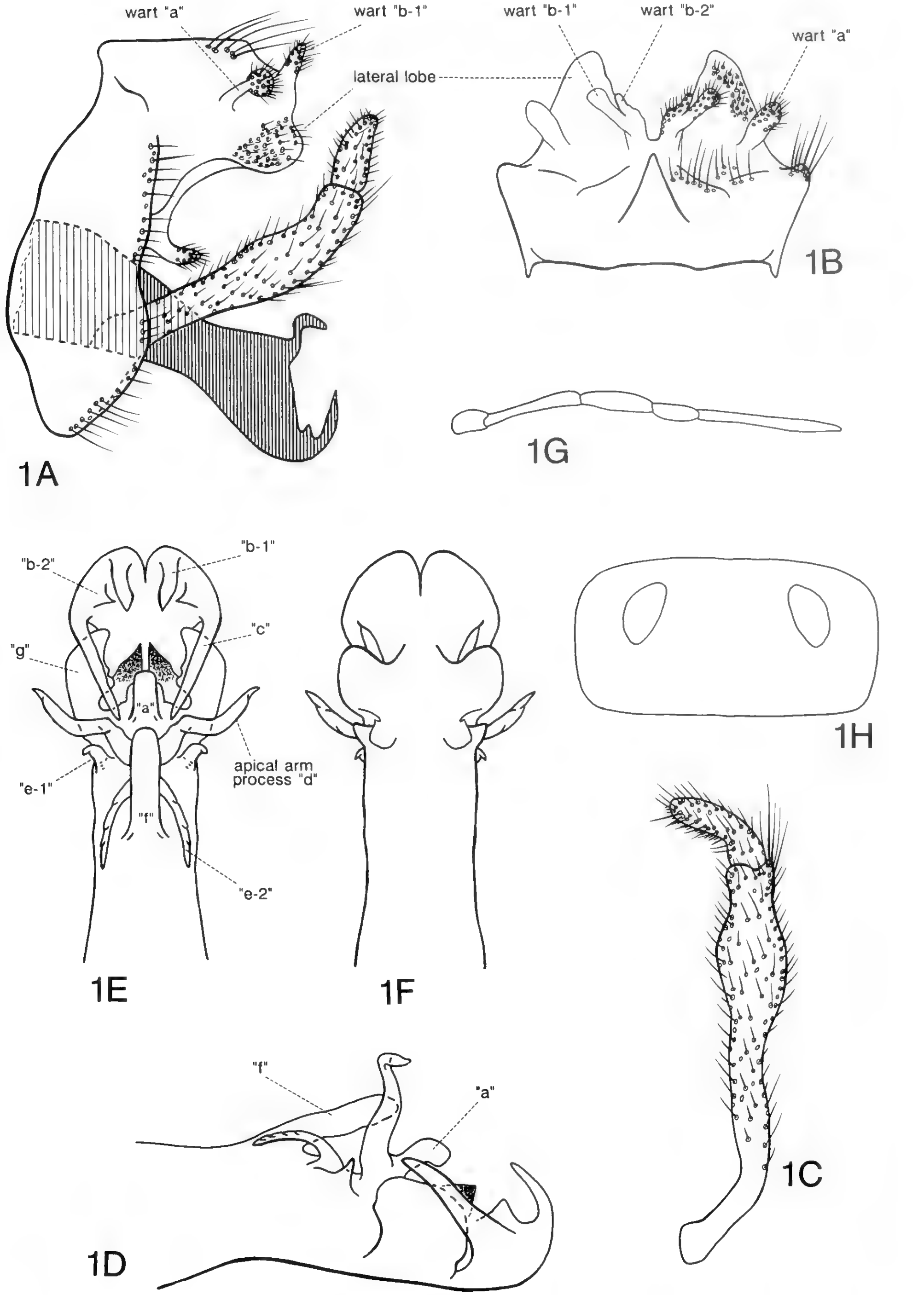


Fig. 1. *Leptonema clorito*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.

(air) NW Dos Ríos, 10.9°N, 85.4°W, el. 640 m, 15—16.iii.1986, Holzenthal and Fasth (NMNH).

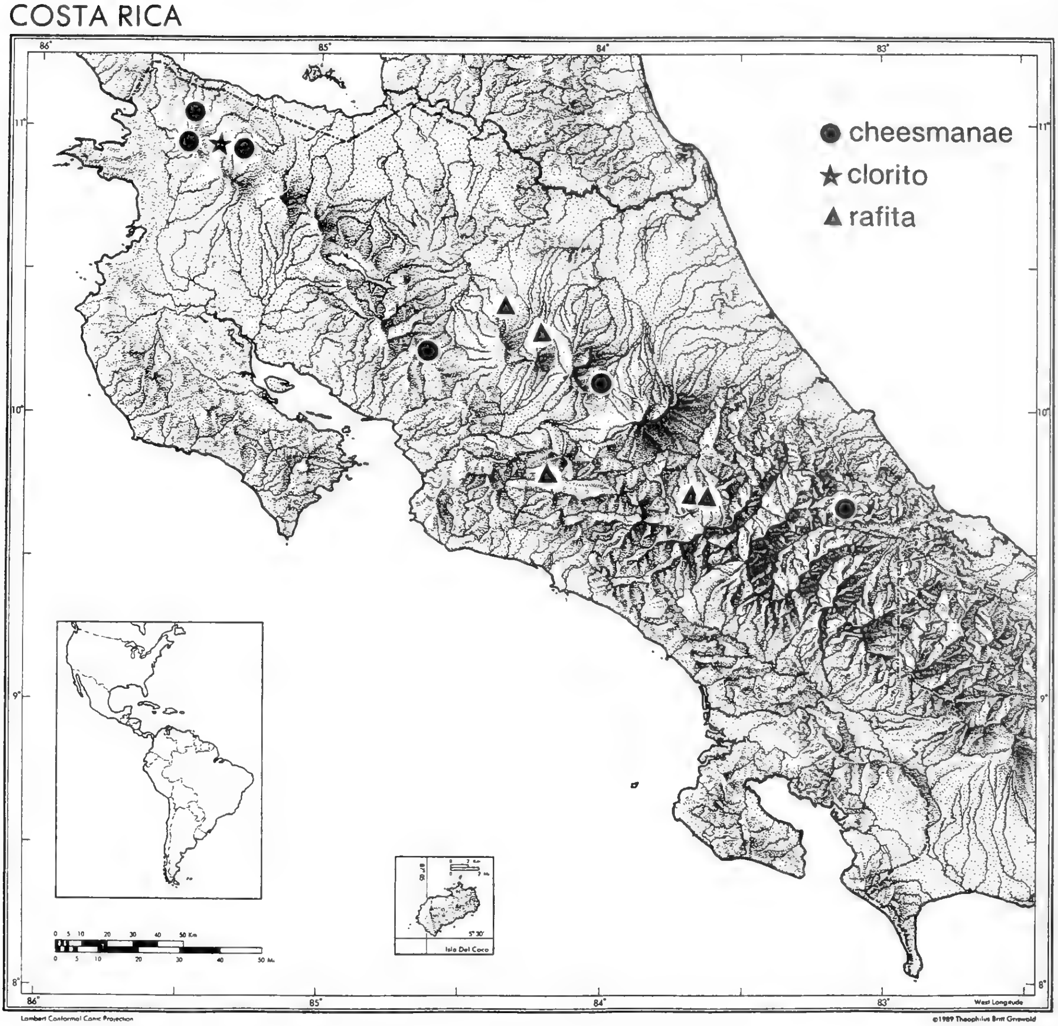
Etymology.—Dedicated to the memory of Dr. Clodomiro Picado Twight (1887–1944), in recognition of his numerous and outstanding contributions to the biology of Costa Rica. Dr. Picado was known affectionately as "Clorito."

Leptonema flintorum **Muñoz-Q.,**
new species

(Fig. 2, Map 2)

Diagnosis.—This species is a member of the *plicatum* Group, as defined by Flint et al. (1987). It is very similar to *L. huismanae* n. sp., but differs in the shape and size of process "*g*" of the phallic apparatus. In *L. flintorum*, process "*g*" is narrow, elongate, distinctly concave dorsally, with a slightly rounded and slightly serrated apex, barely reaching the posterior margin of process "*b*". In *L. huismanae*, process "*g*" is larger, very broad, slightly concave middorsally, with a broad, rounded, serrated apex, generally extending beyond the posterior margin of process "*b*". Additionally, the midsection of the phallus of *L. flintorum* is wider than that of *L. huismanae*. Also, process "*e*" of the phallus of *L. flintorum* is more robust and conspicuous than the same process in *L. huismanae*. The pattern of brownish setae on the forewing of *L. huismanae* is darker than the pattern in *L. flintorum*. *Leptonema flintorum* has only been collected in the southern region of Costa Rica; *L. huismanae* has been collected in the central and northern regions of the country. Finally, *L. flintorum* and *L. huismanae* can be separated from *L. sinuatum* Mosely by the shape of process "*a*" and by the presence or absence of processes "*e*" and "*f*" of the phallus; these latter two processes also separate two the new species from *L. hamuli* Flint, McAlpine, and Ross. In *L. flintorum* and *L. huismanae*, process "*a*" arises dorsally, is broad, membranous, emarginate apicomesally and without conspicuous, dorsomesal, projections; in *L. sinuatum*, process "*a*" has a pair of conspicuous, dorsomesal, curved projections, which are directed anteriorly, In *L. flintorum* and *L. huismanae*, process "*e*" is present and process "*f*" is absent, as viewed dorsally. In *L. hamuli* and *L. sinuatum*, process "*e*" is absent and process "*f*" is present.

Description.—*Male:* Length of forewing 20–22 mm. Body sclerites pale brown. Dorsum of head pale brown with short, light brown setae. Legs with fine, light brown setae. Wings light brown, translucent; forewing covered with fine, short, brown setae, with darker brown setae along anal veins, and transverse band of darker brown setae over cord. Maxillary palpus with fifth segment more than ½ length of basal 4 segments combined. Process of sternum V large, oval. *Genitalia* (Fig. 2): Segment IX, as viewed laterally, narrow, elongate, with V-shaped dorsal keel. Segment X with wart "*a*" elongate, base narrow, apex bulbous; warts "*b-1*" and "*b-2*" elongate, base narrow, apex bulbous; wart "*c*" absent; lateral lobes, as viewed dorsally, sharply pointed, projecting posteriorly; as viewed laterally, appearing triangular, bearing short setae on lateral margin. Inferior appendage two segmented, basal segment more than 3 times length of apical segment; apical segment with short setae on inner margin. Phallus long, tubular; midsection bearing process "*e*" dorsolaterally, slightly narrower than apical section of phallus (apical section less than 1.5 times width of midsection); apical section bearing two, tiny, sharply pointed, sclerotized phallotremal sclerites behind process "*a*", visible in dorsal view; process "*a*", as viewed dorsally, broad, membranous, arising dorsally, and emarginate apicomesally; dorsal lobe of process "*a*" as viewed laterally, with small, lightly sclerotized point, directed dorsally; process "*b*" arising apicoventrally, slender, long, reaching the base of process "*e*", apex pointed; as viewed laterally, arched dorsally; process "*e*" spinelike, robust, conspicuous, arises dorsolaterally, apex pointed, directed anter-



Map 1. Distribution of *Leptonema cheesmanae*, *L. clorito*, and *L. rafita*.

odorsally (in lateral view, height of midsection of phallus less than 2.5 times length of process "*e*"); process "*g*" developed into narrow, elongate, apicolateral lobe, projecting posteriorly, as viewed dorsally, distinctly concave dorsally, apex somewhat rounded, lightly sclerotized, barely reaching posterior margin of process "*b*"; as viewed laterally, slightly serrated on dorsal and ventral margins; ventrally, with U-shaped, apicomesal emargination; processes "*c*", "*d*", "*f*" and "*j*" absent.

Type material.—Holotype: ♂, COSTA RICA: *Puntarenas:* Río Bellavista, ca. 1.5 km NW Las Alturas, 8.951°N, 82.846°W, el. 1400 m, 16–17.iii.1991, Holzenthal, Muñoz, Huisman (NMNH). Paratypes: COSTA RICA: *Puntarenas:* same data as holotype except, 1 ♂, 4 ♀ (UMSP); same except, trib. Río Bellavista, Las Alturas (road to quarry) 8.952°N, 82.848°W, el. 1480 m, 19.iii.1991, Holzenthal, Muñoz, Huisman, 1 ♂ (UMSP).

Etymology.—Named in honor of Dr. Oliver S. Flint and his wife, Mrs. Carol Flint, in recognition to their great labor in the study of the Neotropical caddisfly fauna and their help with the author.

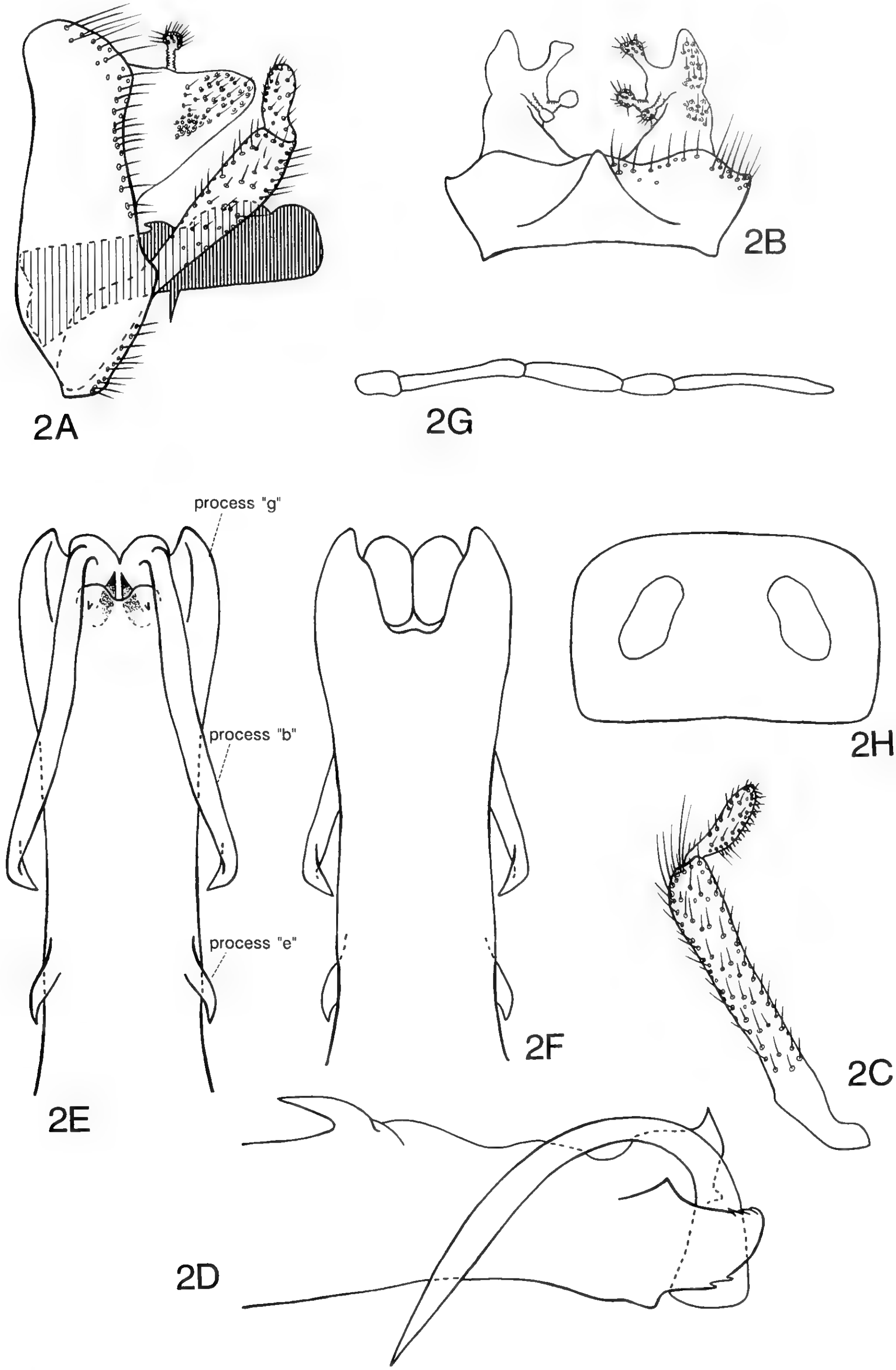


Fig. 2. *Leptonema flintorum*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.

Leptonema huismanae Muñoz-Q., new species

(Fig. 3, Map 2)

Diagnosis.—This species belongs within the *plicatum* Group of Flint et al. (1987). It is closest to *L. flintorum* n. sp., differing from that species in the shape and size of process "*g*" of the phallic apparatus, as well as in the size of process "*e*", and of the width of the midsection of the phallus. Also, these species can be distinguish by the pattern of brownish setae on the forewing, as discussed in the diagnosis of *L. flintorum*. Finally, *L. huismanae* can be distinguished from *L. sinuatum* Mosely by the shape of process "*a*" and by the presence or absence of processes "*e*" and "*f*" of the phallus, these latter two processes also separate it from *L. hamuli* Flint, McAlpine, and Ross, as described in the diagnosis of *L. flintorum*.

Description.—*Male:* Length of forewing 17–20 mm. Body sclerites pale brown. Dorsum of head pale brown with short, light brown setae. Legs with fine, light brown setae. Wings light brown, translucent; forewing covered with fine, short, brown setae, with small transverse band of brownish setae over basal third and with longer, darker, transverse band of brownish setae over cord and margins of medial cell. Maxillary palpus with apical segment more than ½ length of basal 4 segments combined. Process of sternum V large, oval. *Genitalia* (Fig. 3): Segment IX, as viewed laterally, narrow, elongate, with V-shaped dorsal keel. Segment X with wart "*a*" elongate, base narrow, apex bulbous; warts "*b-1*" and "*b-2*" elongate, base narrow, apex bulbous; wart "*c*" absent; lateral lobes, as viewed dorsally, rounded, projecting posteriorly; as viewed laterally, triangular, bearing short setae on lateral margin. Inferior appendage two segmented, basal segment slightly more than 3 times length of apical segment; apical segment with short setae on inner margin. Phallus long, tubular; midsection bearing process "*e*" dorsolaterally, distinctly constricted (apical section more than 2 times width of midsection); apical section distinctly broader, bearing two, tiny, sharply pointed, sclerotized phallotremal sclerites behind process "*a*", visible in dorsal view; process "*a*", as viewed dorsally, broad, membranous, arising dorsally, and emarginate apicomesally; dorsal lobe of process "*a*", as viewed laterally, with small, lightly sclerotized point, directed dorsally; process "*b*" arising apicoventrally, slender, long, extending beyond the base of process "*e*", apex pointed; as viewed laterally, arched dorsally; process "*e*" spinelike, short, arising dorsolaterally, apex pointed, directed anterodorsally, but in some specimens process "*e*" very short to minute (in lateral view, height of midsection of phallus more than 3 times length of process "*e*"); process "*g*" developed into large, very broad, apicolateral lobe, projecting posteriorly, as viewed dorsally, only slightly concave middorsally, apex broad, rounded, serrated, lightly sclerotized, normally extending beyond posterior margin of process "*b*", but in some specimens barely reaching beyond posterior margin of process "*b*"; as viewed laterally, dorsal, apical and ventral margins with many robust serrations, lightly sclerotized; as viewed ventrally, with U-shaped, apicomesal emargination; processes "*c*", "*d*", "*f*" and "*j*" absent.

Type material.—Holotype: ♂, COSTA RICA: *Alajuela:* Reserva Forestal San Ramón, Río San Lorencito and tribs., 10.216°N, 84.607°W, el. 980 m, 6—10.iii.1991, Holzenthal, Muñoz, Huisman (NMNH). Paratypes: COSTA RICA: *Alajuela:* same data as holotype except, 13–16.vi.1986, C.M. and O.S. Flint, Holzenthal, 11 ♂, 2 ♀ (NMNH); same except, 2–4.vii.1986, Holzenthal, Heyn, Armitage, 3 ♂, 3 ♀ (UMSP); same except, 5–9.vii.1986, I. and A. Chacón, 6 ♂, 2 ♀ (UMSP); same except, 2–6.ix.1986, I. and A. Chacón, 1 ♂, 1 ♀ (UMSP); same except, 24–27.ii.1987, I. and A. Chacón, 3 ♂, 1 ♀ (UMSP); same except, 30.iii.–1.iv.1987, Holzenthal, Hamilton, Heyn, 11 ♂ (4 in alcohol), 5 ♀

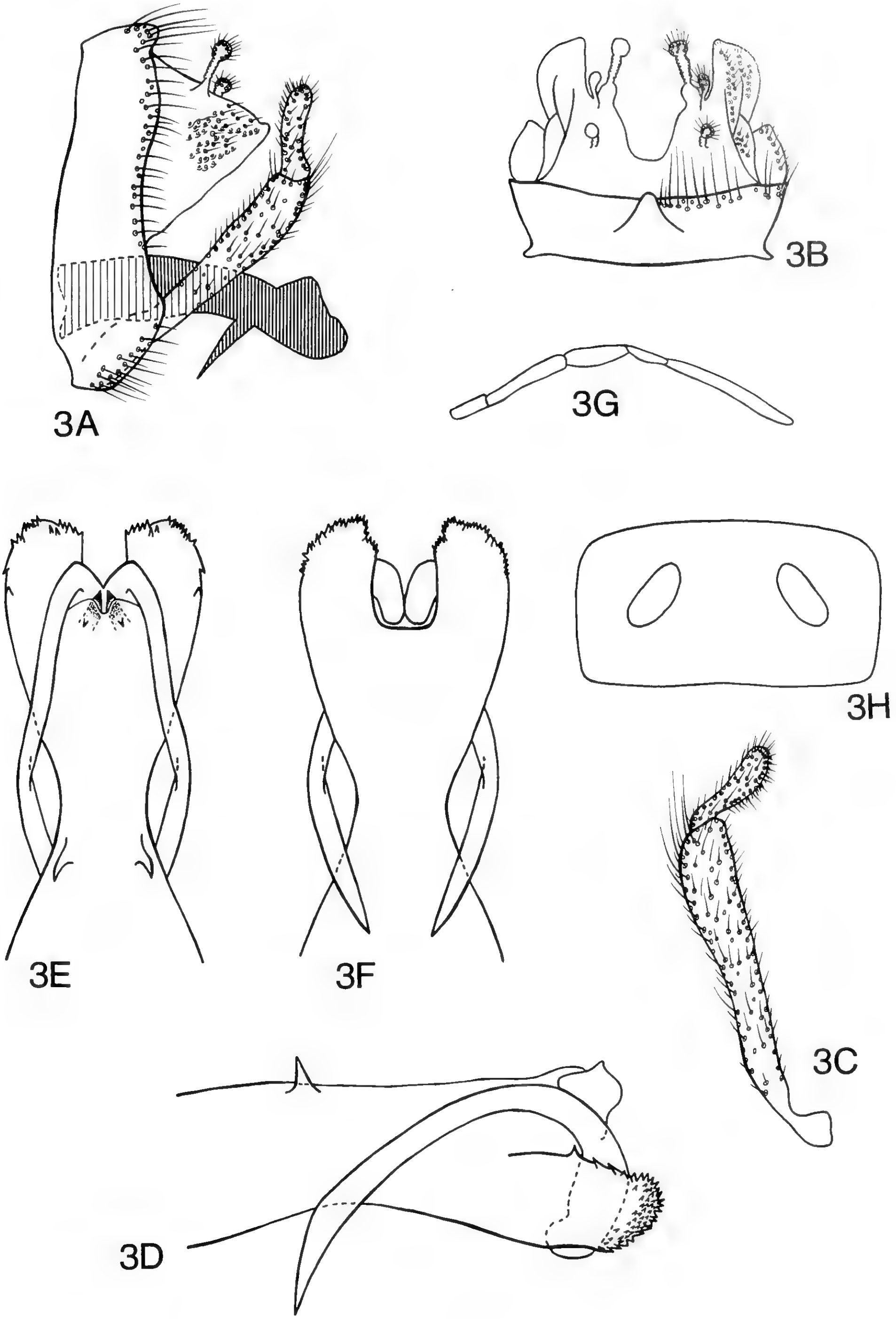


Fig. 3. *Leptonema huismanae*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.

(UMSP); same except, 1–4.v.1990, Holzenthal and Blahnik, 5 ♂ (1 in alcohol), 12 ♀ (UMSP); same except, 28–30.vii.1990, Holzenthal, Blahnik, Muñoz, 1 ♂, 1 ♀ (in alcohol) (UMSP); same data as holotype except, 7 ♂, 10 ♀ (UMSP); Río Sarapiquí, ca. 2 km SE Cariblanco, 10.299°N, 84.172°W, el. 710 m, 22.iii.1986, Holzenthal and Fasth, 1 ♂ (UMSP); same except, 6.ii.1987, I. and A. Chacón, 2 ♂, 2 ♀ (UMSP); Río Agrio, ca. 3.5 km NE Bajos del Toro, 10.243°N, 84.279°W, el. 1290 m, 20.viii.1990, Holzenthal et al., 1 ♂ (UMSP); *Guanacaste:* Parque Nacional Guanacaste, Río San Josecito, Est. Mengo [Estación Cacao], 10.922°N, 85.470°W, el. 960 m, 28–29.vii.1987, Holzenthal, Morse, Clausen, 8 ♂, 4 ♀ (UMSP); same except, Estación Cacao, lado suroeste del Volcán Cacao, [10°56′N, 85°26′W], el. 1000–1400 m, ix–xii.1989, URCG, R. Blanco, C. Chávez, 3 ♂ (INBIO); same except, vi.1990, II Curso de Parataxónomos, 14 ♂, 12 ♀ (INBIO); Z.[ona] P.[rotectora] Tenorio, tribs. Río San Lorenzo, 6 km NW Tierras Morenas [Tilarán], 10.61°N, 84.98°W, el. 900 m, 17–19.ii.1992, Holzenthal, Muñoz, Kjer, 3 ♂, 10 ♀ (UMSP).

Etymology.—Named in honor of Jolanda Huisman, in recognition of her great help with the Trichoptera of Costa Rica Project and for her friendship.

Leptonema rafita Muñoz-Q., new species

(Fig. 4, Map 1)

Diagnosis.—This species is also a member of *plicatum* Group, as defined by Flint et al. (1987). It is most similar to *L. ekisi* Flint, McAlpine, and Ross, *L. fortunum* Flint, McAlpine, and Ross, *L. salvini* Mosely, and *L. vitum* Flint, McAlpine, and Ross, differing from those species in the shape of process "*f*" of the phallic apparatus. In *L. rafita*, as viewed dorsally, process "*f*" arises dorsomesally and is round; as viewed laterally, it is short, erect, with an apex moderately rounded and directed dorsally; in *L. ekisi*, as viewed dorsally, process "*f*" is elongate, tonguelike, with its apex directed posteriorly; in *L. fortunum*, as viewed dorsally, process "*f*" is somewhat elongate, with a bifid apex directed posteriorly; in *L. salvini*, as viewed dorsally, process "*f*" is oval; as viewed laterally, it is short, and with its apex slightly rounded and directed dorsally; and in *L. vitum*, process "*f*" is absent. Also, process "*g*" of the phallus is unilobed in *L. salvini*, and it is bilobed in *L. rafita*, *L. ekisi*, *L. fortunum* and *L. vitum*. In addition, process "*g*" is different among the four species. In *L. rafita*, process "*g*" is short, lightly sclerotized, arising apicolaterally, directed posteriorly, and bilobed; as viewed laterally, the apical lobe of process "*g*" is erect, subtriangular, strongly serrated, projected posteriorly, with a pair of apical points that reach the posterior margin of the process "*b*"; the dorsal lobe of the process "*g*" is erect, subtriangular, slightly serrated, directed dorsally and with a pointed apex; in *L. ekisi*, process "*g*" is short, apicolateral, directed posteriorly and bilobed apically; as viewed laterally, the apical lobe is short, rounded, unserrated, projected posteriorly, and barely reaching the posterior margin of process "*b*"; the dorsal lobe is subtriangular, directed dorsally with small apical points; in *L. fortunum*, process "*g*" is elongate, apicolateral, projected posteriorly beyond the posterior margin of process "*b*", and bilobed apically; as viewed laterally, the apical lobe is subtriangular, unserrated, with a pointed apex and directed posteriorly; the dorsal lobe is erect, subtriangular, unserrated, with a pointed apex and directed dorsally; in *L. salvini*, process "*g*" is unilobed, short, apicolateral; as viewed laterally, projected posteriorly, reaching the posterior margin of process "*b*"; the apical lobe is absent; and the dorsal lobe is erect, subtriangular, dorsoapical, and directed dorsally; and in *L. vitum*, process "*g*" is elongate, apicolateral, projected posteriorly beyond of posterior margin of process "*b*", and bilobed; the apical lobe, as viewed laterally, is large, quadrate, serrated posterodorsally and directed posteriorly; as viewed dorsally, with apex directed posteromesally and the dorsal emerging mesally; the dorsal lobe, as viewed laterally, is erect, slender, and directed dorsally. Finally, in both *L. rafita* and *L. salvini*, process "*e*" of the phallus, as viewed laterally, reaches the base of the process "*f*"; in *L. ekisi*, it does not reach the base of process "*f*" and in *L. fortunum*, it is absent. Finally, in *L. vitum*. process "*f*" is absent.

Description.—*Male:* Length of forewing 20–23 mm. Body sclerites pale brown. Dorsum of head pale brown with short, light brown setae. Leg segments with fine, light brown setae. Wings light brown, translucent; forewing covered with fine, short, brown setae, with small, rounded patch of brownish setae over posterior margin of medial cell. Maxillary palpus with apical segment more than ½ length of basal 4 segments combined. Process of sternum V large, oval. *Genitalia* (Fig. 4): Segment IX, as viewed laterally, narrow, elongate, with V-shaped dorsal keel. Segment X with wart "*a*" short with short setae; wart "*b-1*" short with short setae; wart "*b-2*" elongate, base narrow, apex bulbous; wart "*c*" absent; lateral lobes, as viewed dorsally, rounded, projecting posteriorly, bearing short setae; as viewed laterally, rounded, bearing short setae on lateral margin. Inferior appendage two segmented, basal segment more than 3 times length of apical segment; apical segment with short setae on inner margin. Phallus with midsection long, tubular; apical section bearing two, tiny, sharply pointed, sclerotized phallotremal sclerites behind process "*a*", visible in dorsal view; process "*a*", as viewed dorsally, subtriangular, membranous, arising dorsomesally, and emarginate apicomesally; as viewed laterally, with margin rounded; process "*b*" long, broad, tubular, sinuous, emerging apicoventrally, apex rounded, with small point, reaching base of process "*f*", posteroventral section serrated, lightly sclerotized, as viewed laterally, arched, elevated over process "*e*", projecting anteriorly; process "*e*" dorsolateral, fused to phallobase, with elongate, lateral row of spicules and ending in membranous, rounded, dorsolateral, spiculose lobe, reaching base of process "*f*", as viewed laterally; process "*f*", as viewed dorsally, rounded and arising dorsomesally; as viewed laterally, short, erect, apex moderately rounded, directed dorsally; process "*g*" apicolateral, short, lightly sclerotized, directed posteriorly, bilobed; apical lobe of process "*g*" as viewed laterally, subtriangular, erect, strongly serrated, projected posteriorly, with pair of apical points reaching posterior margin of process "*b*"; dorsal lobe of process "*g*" subtriangular, erect, slightly serrated, with apex pointed directed dorsally; ventrally, with deep, serrated, U-shaped, apical emargination; processes "*c*", "*d*" and "*j*" absent.

Type material.—Holotype: ♂, COSTA RICA: *Alajuela:* Río Peje and falls, ca. 1 km SE San Vicente, Ciudad Quesada, 10.277°N, 84.388°W, el. 1450 m, 14–15.ii.1992, Holzenthal, Muñoz, Kjer (NMNH). Paratypes: COSTA RICA: *Alajuela:* Río Toro, 3.0 km (road) SW Bajos del Toro, 10.204°N, 84.316°W, el. 1530 m, 11.ii.1992, Holzenthal, Muñoz, Kjer, 1 ♂ (UMSP); same data as holotype except, 4 ♂, 4 ♀ (UMSP); *Cartago:* Reserva Tapantí, Río Grande de Orosi, 9.686°N, 83.756°W, el. 1650 m, 15–16.vii.1987, Holzenthal, Morse, Clausen, 1 ♂ (UMSP); same except, Quebrada Palmitos and falls, 9.72°N, 83.78°W, 1400 m, 1–2.viii.1990, Holzenthal, Blahnik, Muñoz, 1 ♂, 1 ♀ (UMSP); same except, 21.ii.1992, Holzenthal, Muñoz, Kjer, 1 ♂, 1 ♀ (INBIO); same except, waterfalls, ca. 1 km (road) NW tunnel, 9.69°N, 83.76°W, 1600 m, 2–3.viii.1990, Holzenthal, Blahnik, Muñoz, 1 ♂ (NMNH); *San José:* trib. to Quebrada Caraigres 3.6 km (road) SW La Legua, 9.728°N, 84.125°W, el. 1650 m, 23.i.1992, Holzenthal, Kjer, Quesada, 2 ♂ (UMSP).

Etymology.—Named in honor of Dr. Ralph W. Holzenthal, who first introduced me to the Neotropical caddisfly world.

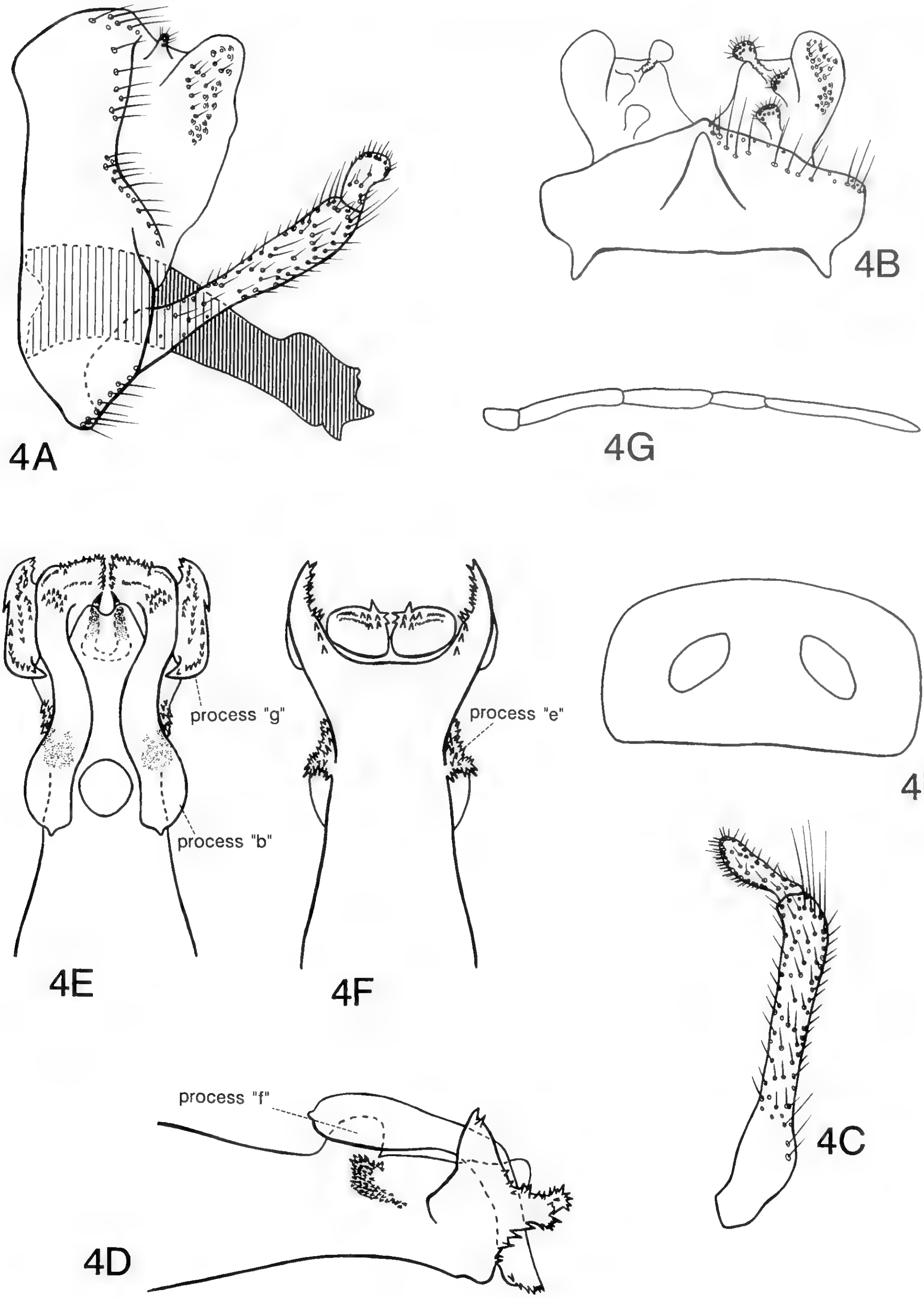
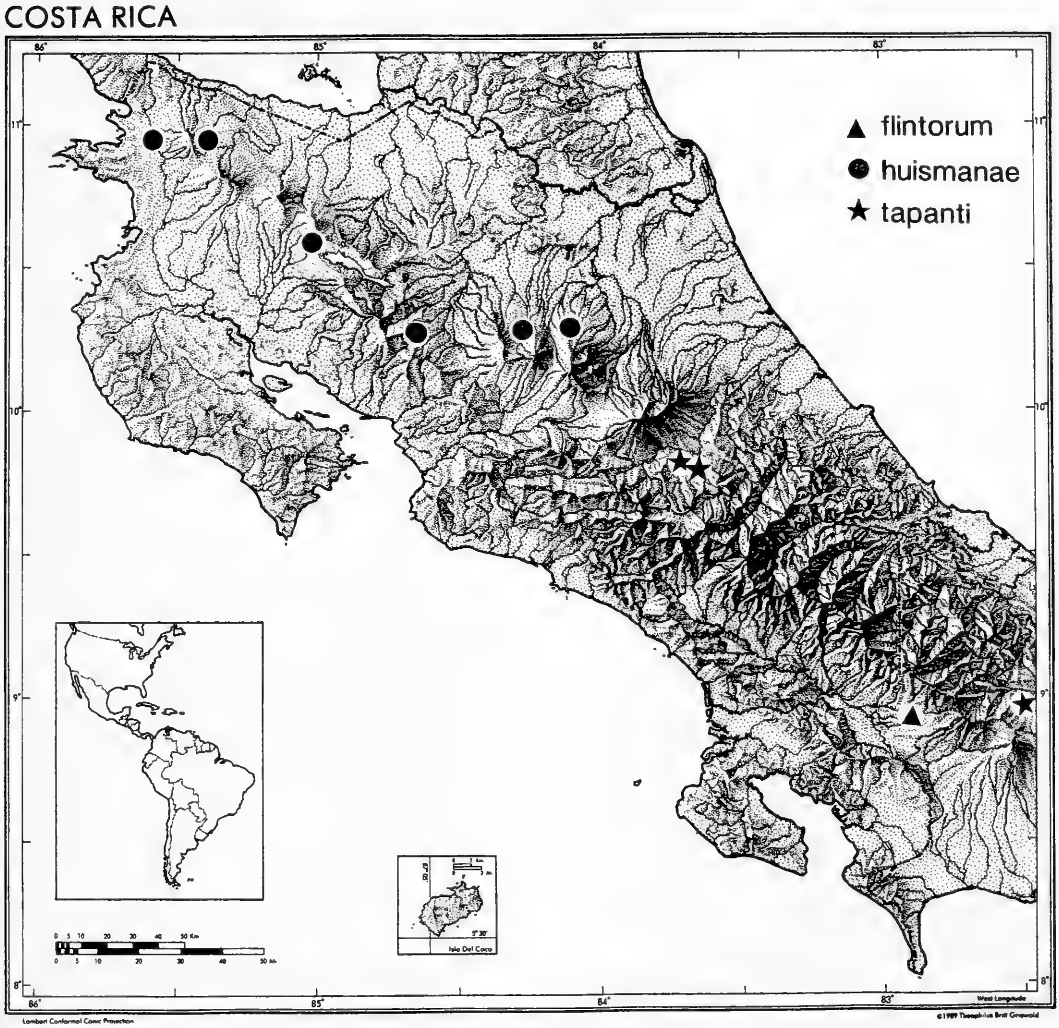


Fig. 4. *Leptonema rafita*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.



Map 2. Distribution of *Leptonema flintorum*, *L. huismanae*, and *L. tapanti*.

Also, Dr. Holzenthal has added enormously to the knowledge of the caddisfly fauna of Costa Rica, where he is called affectionately "Rafita."

Leptonema tapanti Muñoz-Q., new species
(Fig. 5, Map 2)

Diagnosis.—*Leptonema tapanti* is the first species of the *stigmosum* Group of Flint et al. (1987) recorded from Costa Rica. This new species is close to *L. auriculatum* Flint, McAlpine, and Ross of the same group, but is also similar to *L. michoacanense* Flint, McAlpine, and Ross, *L. plicatum* Mosely, and *L. simplex* Mosely of the *plicatum* Group. However, it can be distinguished from those species by the shape of processes "*b*" and "*c*" of the phallus. In *L. tapanti*, processes "*b*" and "*c*" are fused into a lightly sclerotized, apicolateral, inflated, paired lobes; as viewed dorsally, process "*b-c*" is earlike, enlarged, and concave dorsolaterally at its middle. The lateral margin is convexly curved, with the apices pointed and directed posteriorly, and with a slender, curved, midlateral projection. In *L. auriculatum*, *L. michoacanense*, *L. plica-*

tum, and *L. simplex*, processes "*b*" and "*c*" are not fused. In *L. auriculatum*, process "*b*" is a small dorsal angle; process "*c*" is smaller, rounded, and earlike; in *L. michoacanense*, process "*b*" is long, slender, basally curved and with a pointed apex; process "*c*" is shorter, slender, curved basally; in *L. plicatum*, process "*b*" is long, slender, curved basally and with a pointed apex; process "*c*" is absent; and in *L. simplex*, process "*b*" is short; as viewed laterally, it is subtriangular with a pointed apex directed anterodorsally; process "*c*" is absent. Finally, in this new species, as viewed dorsally, process "*b-c*" has a slender, curved, midlateral projection, with the apex pointed and directed mesally; a similar projection is absent in the other species.

Description.—*Male:* Length of forewing 17–20 mm. Body sclerites pale brown. Dorsum of head pale brown with short, light brown setae. Leg segments with fine, light brown setae. Wings light brown, translucent; forewing sparsely covered, mainly between anal veins, with fine, short, brown setae, with two small rounded patches of darker setae, one over each nygma. Maxillary palpus with fifth segment about ½ length of basal 4 segments combined. Process of sternum V very small, circular. *Genitalia* (Fig. 5): Segment IX, as viewed laterally, narrow, elongate; as viewed dorsally, with V-shaped dorsal keel, dorsal margin slightly projecting posteromesally. Segment X with wart "*a*" absent; warts "*b-1*" and "*b-2*" short with small setae; wart "*c*" absent; lateral lobes, as viewed dorsally, each with pair of apical points, projecting posteriorly; as viewed laterally, bearing short setae on lateral margin. Inferior appendage two segmented, basal segment less than 3 times length of apical segment; apical segment with short setae on inner margin. Phallus with midsection long, tubular; apical section bearing two, tiny, sharply pointed, sclerotized phallotremal sclerites behind process "*a*", visible in dorsal view; process "*a*", as viewed dorsally, broad, rounded, membranous, arising dorsomesally, and emarginate apicomesally, trilobed; lateral lobes of process "*a*" broad, with lateral margin slightly convex; mesal lobe of process "*a*" slender; as viewed laterally, lateral lobes of process "*a*", rounded and directed dorsally; mesal lobe of process "*a*" rounded, higher, directed anterodorsally, and reaching posteromesal spicules of mesal row of spicules of process "*e*"; processes "*b*" and "*c*" fused into lightly sclerotized, apicolateral, inflated, paired lobes; as viewed dorsally, process "*b-c*" earlike, enlarged, concave dorsolaterally at middle, lateral margin convexly curved, apices pointed, directed posteriorly, and with slender, curved, midlateral projection with pointed apex, directed mesally; ventrally, with deep, narrowly V-shaped, apicomesal emargination; process "*e*" dorsolateral, fused to phallobase; as viewed dorsally, developed into three elongated rows of spicules, one mesal and Y-shaped, and two lateral ones ending in rounded, membranous, dorsal, and anteriorly directed lobes, with small spicules; processes "*d*", "*f*", "*g*" and "*j*" absent.

Type material.—Holotype: ♂ COSTA RICA: *Cartago:* Reserva Tapantí, Quebrada Palmitos and falls, 9.72°N, 83.78°W, 1400 m, 24–25.iii.1991, Holzenthal, Muñoz, Huisman (NMNH). Paratypes: COSTA RICA: *Cartago:* same data as holotype except, Río Grande de Orosi, 9.686°N, 83.756°W, el. 1650 m, 18–21.iii.1987, Holzenthal, Hamilton, Heyn, 1 ♂, 1 ♀ (UMSP); same except, Río Dos Amigos and falls, ca. 6 km (road) NW tunnel, 9.704°N, 83.783°W, 1500 m, 23.iii.1991, Holzenthal, Muñoz, Huisman 1 ♂, 1 ♀ (UMSP); same data as holotype except, 10 ♂, 2 ♀ (UMSP); same except, 21.ii.1992, Holzenthal, Muñoz Kjer, 1 ♂, 3 ♀ (INBIO). PANAMA: *Chiriquí:* Guadalupe Arriba, 8°52′26″N, 82°33′13″W, 1–28.ii.1984, H. Wolda, 3 ♂, 4 ♀ (NMNH); same except, 29.ii.–27.iii.1984, 3 ♂, 5 ♀ (NMNH); same except, 3–30.iv.1984, 1 ♂, 8 ♀ (NMNH); same except, 2–29.v.1984, 2 ♂, 3 ♀ (NMNH); same except, 30.v.–19.vi.1984, 2

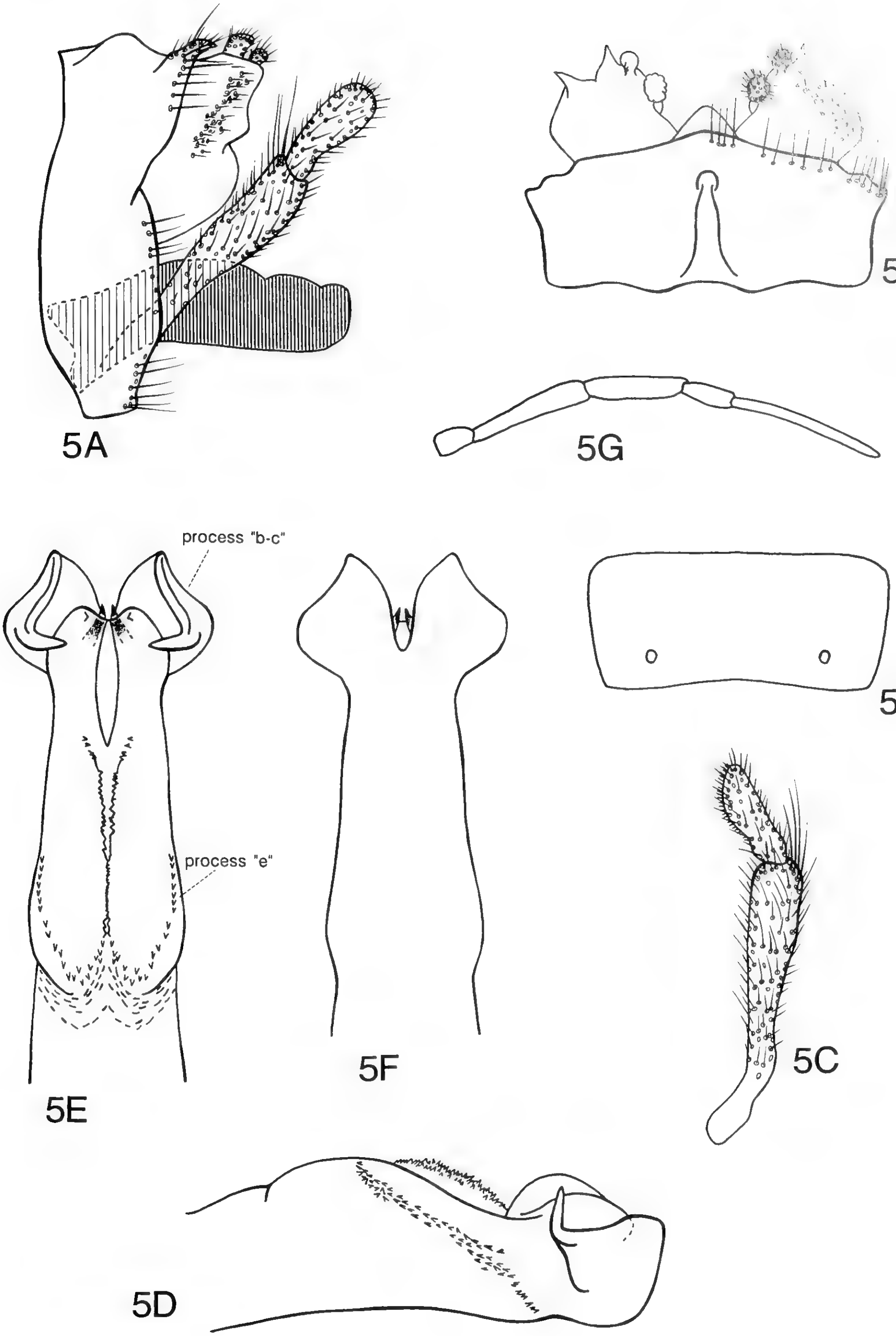


Fig. 5. *Leptonema tapanti*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.

♂ (NMNH); same except, 15–28.v.1985, 2 ♂, 2 ♀ (NMNH); same except, 15–18.vi.1985, 3 ♂ (NMNH); same except, 14–29.viii.1985, 1 ♂, 1 ♀ (NMNH).

Etymology.—Named for the type locality, Tapantí National Park, which has a rich and endemic caddisfly fauna.

Leptonema cheesmanae Mosely
(Fig. 6, Map 1)

Leptonema cheesmanae Mosely 1933: 51–52, figs. 148–153, ♂, I. Gorgona, Colombia (BMNH); McElravy et al. 1981: 153; 1982: 307.

Distribution.—Colombia, Panama, Costa Rica (new record).

Diagnosis.—This species is a member of the *complexum* Group, as defined by Flint et al. (1987). *Leptonema cheesmanae* is very similar to *L. clorito* n. sp., differing from that species in the shape of process "*d*" of the phallic apparatus and the shape of the lateral lobes of segment X, as viewed dorsally, as described in the diagnosis of *L. clorito*. Also, this species can be separated from *L. harpagum* Flint, McAlpine, and Ross by the shape of process "*a*", which in *L. cheesmanae*, is unilobed, as viewed dorsally, process "*a*" is tonguelike, elongate, slender and arising dorsomesally; as viewed laterally, it is fingerlike, arched, with the apex truncated. In *L. harpagum*, process "*a*" is bilobed and prominent. In figure 153 from Mosely (1933) of *L. cheesmanae*, process "*f*" is not illustrated, but it does appear in his figure 152. However, in figure 152 it is not possible to see process "*e-1*", only process "*e-2*".

New distribution records.—COSTA RICA: *Alajuela:* Cerro Campana, ca. 6 km (air) NW Dos Ríos, 10.9°N, 85.4°W, el. 640 m, 15–16.iii.1986, Holzenthal and Fasth, 1 ♂ (UMSP); Reserva Forestal San Ramón, Río San Lorencito and tribs., 10.216°N, 84.607°W, el. 980 m, 2–4.vii.1986, Holzenthal, Heyn, Armitage, 5 ♂ (UMSP); same except, 5–9.vii.1986, I. and A. Chacón, 1 ♂ (UMSP); same except, 2–6.ix.1986, I. and A. Chacón, 9 ♂, 11 ♀ (UMSP); same except, 1–4.vii.1986, I. and A. Chacón, 2 ♂, 1 ♀ (UMSP); same except, 24–27.ii.1987, I. and A. Chacón, 2 ♂ (UMSP); same except, 30.iii.1987, Holzenthal, Hamilton, Heyn, 2 ♂ (in alcohol) (INBIO); same except, 1–4.v.1990, Holzenthal, Blahnik, 28 ♂ (10 in alcohol), 3 ♀ (UMSP); same except, 28–30.vii.1990, Holzenthal, Blahnik, Muñoz, 3 ♂, 12 ♀ (UMSP); same except, 6–10.iii.1991, Holzenthal, Muñoz, Huisman, 4 ♂, 9 ♀ (UMSP); *Guanacaste:* Parque Nacional Guanacaste, Estación Pitilla, Río Orosi, 10.991°N, 85.428°W, el. 700 m, 22–25.v.1990, Holzenthal and Blahnik, 1 ♂ (UMSP); same except, Estación Maritza, Río Tempisquito, 10.958°N, 85.497°W, el. 550 m, 16.ii.1994, F. Muñoz-Q., 4 ♂, 3 ♀ (in alcohol) (INBIO); *Limón:* Reserva Biológica Hitoy Cerere, Estación Miramar, 9.671°N, 83.030°W, el. 550 m, 11.xii.1990, F. Muñoz-Q., 1 ♂ (UMSP); *San José:* P.[arque] N.[acional] Braulio Carrillo, Est.[ación] Carrillo, Q.[uebrada] Sanguijuela, 10.160°N, 83.963°W, el. 800 m, 22–28.viii.1986, I. and A. Chacón, 3 ♂, 1 ♀ (UMSP); same except, 27.iii.1987, Holzenthal, Hamilton, Heyn, 4 ♂ (UMSP).

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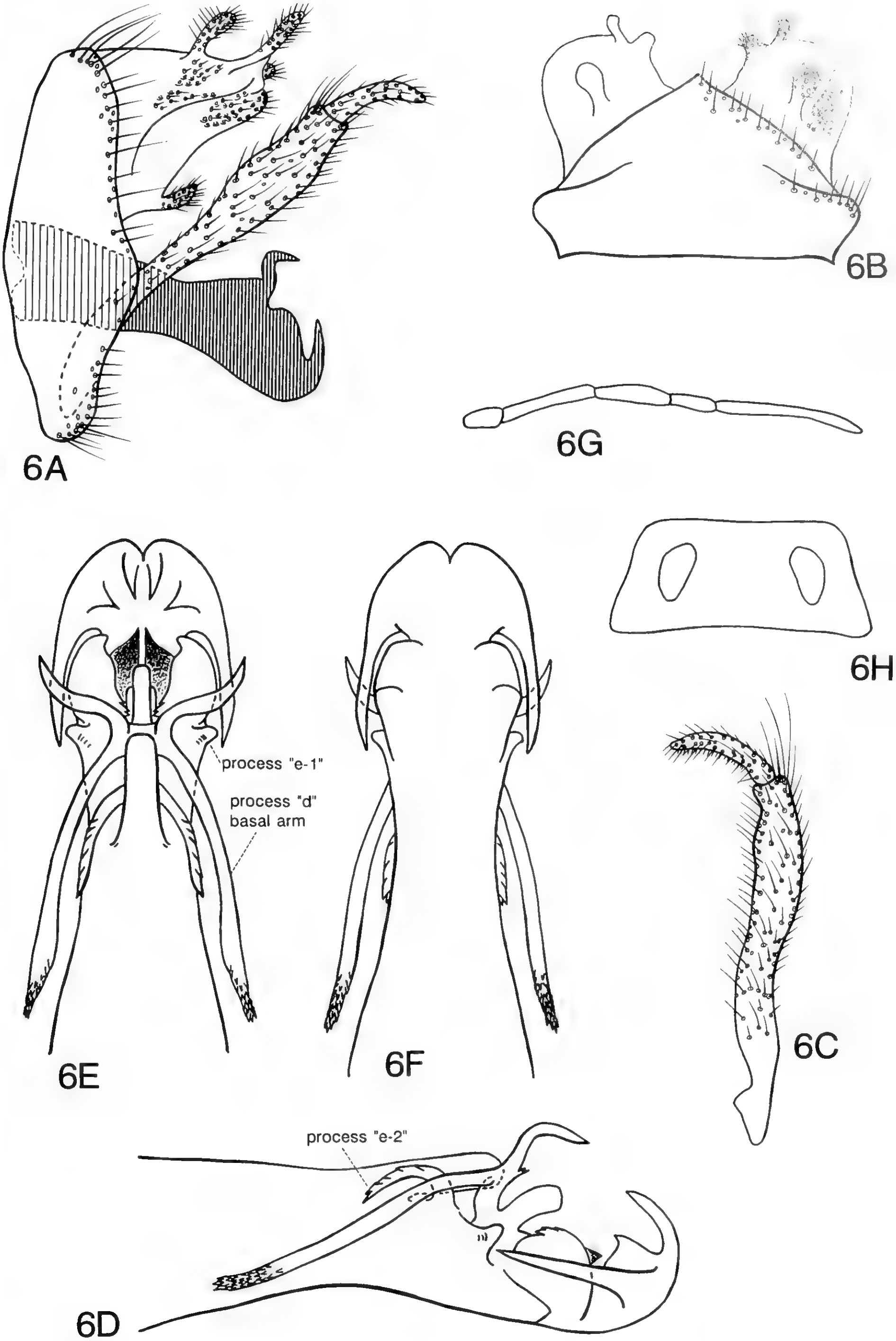

Fig. 6. *Leptonema cheesmanae*, male genitalia. A, Lateral view. B, Segments IX, X, dorsal view. C, Inferior appendage, posteroventral view. D, Phallus, lateral view. E, Phallus, dorsal view. F, Phallus, ventral view. G, Maxillary palpus, lateral view. H, Sternum V, ventral view.

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99(1), 1997, pp. 133–135

A NEW *AMMOPLANUS* GUSSAKOVSKIJ (HYMENOPTERA: SPHECIDAE: PEMPHREDONINAE) FROM SAN CLEMENTE ISLAND, CALIFORNIA

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Abstract.—***Ammoplanus clemente*, n. sp.**, is described from a single female from San Clemente Island, California. This is the first record of the genus from the Channel Islands of California.

Key Words: *Ammoplanus, clemente*, San Clemente Island, California Channel Islands

In North America, the genus *Ammoplanus* Gussakovskij as defined by Bohart and Menke (1976) is represented by seven described species. Except for *A. unami* Pate from Pennsylvania, Virginia, and West Virginia, the species occur in the western United States, especially in southern California. Pate (1943) provided an illustrated key to them, but little has been done with the genus in North America since his work. Krombein (1956) described the formerly unknown male of *A. unami*. Only two species are known from both sexes, *A. chemehuevi* Pate and *A. unami*. *Ammoplanus loti* Pate, *A. quabajai* Pate, and *A. vanyumi* Pate are known by females, and *A. sechi* Pate and *A. tetli* Pate by males.

Marshakov (1979) treated the genus *Ammoplanellus* Gussakovskij sensu Bohart and Menke (1976) as a subgenus of *Ammoplanus*. Marshakov's action probably has merit but I have not investigated the matter. *Ammoplanellus* differs from *Ammoplanus* in having the marginal cell open along the wing margin, and thus none of the four North American species of *Ammoplanellus* sensu Marshakov can be confused with the new species of described below.

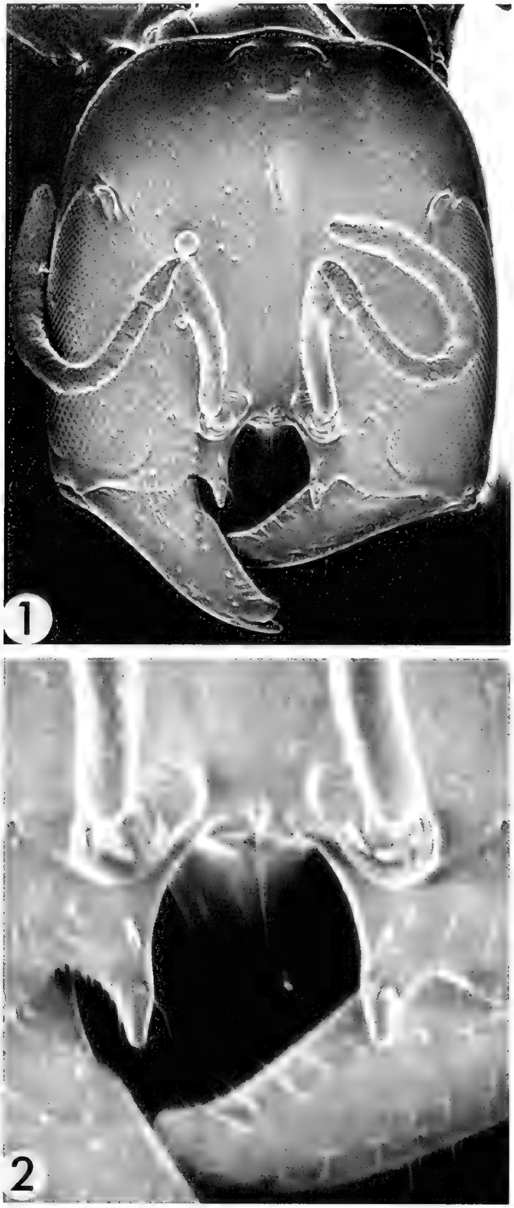
Ammoplanus is unrecorded from the California Channel Islands (Rust et al. 1985). The purpose of this paper is to describe a new species from San Clemente Island so a name will be available to workers studying this insular fauna.

The holotype is deposited in the National Museum of Natural History, Washington, D.C. Sculpture terminology used here is from Harris (1979).

I thank Scott Miller, Bishop Museum, Honolulu; Alex Antropov, Moscow State University, Moscow; R. M. Bohart, University of California, Davis; W. J. Pulawski, California Academy of Sciences, San Francisco; and Steve Nakahara and Ron Hodges, Systematic Entomology Laboratory, USDA, Beltsville, MD, and Washington, DC, for reviewing the manuscript.

Ammoplanus clemente Menke, new species

Holotype female.—Black; mandible pale amber, scape amber, clypeal lobe reddish amber, tarsi brown; stigma uniformly, costa and subcosta of forewing dark brown, other veins paler. Body sparsely setose except se-



Figs. 1–2. *Ammoplanus clemente*, holotype; uncoated SEM photographs. 1, Face. 2, Clypeal notch.

tae denser on legs and apex of gaster. Facial proportions and shape as in Fig. 1; clypeus with broad, parallel-sided, U-shaped emargination at base of which a tiny tubercle bears a long seta that projects into emargination (Figs. 1–2); emargination bounded distally by pair of acuminate lobes (Figs. 1–2); clypeal surface polished, smooth; lower frons coriaceous, upper frons, vertex and gena smooth, polished, sparsely, shallowly punctate (punctures 2 or more diameters apart, mostly 4 or more); midline of frons deeply impressed at level of eye tops (does not show in Fig. 1); frons along inner orbit at eye top with deep, narrow impression that delimits an oval area next to eye (Fig. 1); labrum longer than wide, with narrow U-shaped emargination; mandible apically bidentate; ventral surface of head shallowly, transversely concave at level of hypostomal apex; gena between mandible socket and occipital carina vaguely microstrigulate. Pronotum coriaceous; scutum, scutellum, metanotum, and mesopleuron polished although scutum vaguely coriaceous; metapleuron duller, closely micropunctate. Propodeal dorsum opaque, with median longitudinal carina; propodeal side dull, closely obliquely microridged, these extending partially onto hindface with polished center. Gaster polished, tergum VI with triangular pygidial plate, surface sparsely setose, apex rounded. Length 2.75 mm.

Discussion.—*Ammoplanus clemente* is known only from the female type. The parallel-sided U-shaped clypeal notch with a long basomedian seta immediately distinguishes it from females of *A. chemehuevi*, *A. loti*, *A. quabajai*, *A. unami*, and *A. vanyumi*. Furthermore, the clypeal notch of *A. clemente* lacks the basomedian tooth found in *A. quabajai* and *A. vanyumi*. Other important features of *A. clemente* are the oval area at the inner apex of the eye delimited by a sharp depression, the deep linear depression of the frons, the smooth, polished mesopleuron, and the obliquely microridged propodeal side. It is possible that *A. clemente* is the female of either *A. sechi* or *A. tetli*, but based on comparisons with Pate's descriptions of the two males, this appears unlikely.

It is impossible to know if *A. clemente* is endemic to San Clemente Island. That will have to await the results of further collecting and a much needed revision of North American *Ammoplanus*.

Etymology.—The species name is based on the island from which it comes. It is a noun in apposition.

Type locality.—California, San Clemente I., Horse Canyon, June 17, 1978, A. S. Menke, D. R. Miller and R. W. Rust collectors.

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THE NEW WORLD ALYDINE GENUS *STACHYOCNEMUS* STÅL (HEMIPTERA: ALYDIDAE)

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Abstract.—*Stachyocnemus* is redescribed, and its relationships discussed; except perhaps for *Tollius*, *Stachyocnemus* appears to have no close relatives in North America, Mexico, or Cuba which encompass the known range of the genus. A specimen from Cuba represents a new country record, and specimens from Connecticut are a new state record. Of the two taxa proposed in the genus, *S. cinereus* Fracker is synonymized with *S. apicalis* (Dallas), which is redescribed.

Key Words: Alydidae, Heteroptera, *Stachyocnemus*, genital capsule, Nearctic Region, Cuba

Stachyocnemus is a genus of small distinctive alydines. Although not uncommon, members of the genus live on the ground (in dry areas) and are not often collected. The genus is Nearctic and extends into southern Mexico; it also occurs in Cuba (this paper). There have been two species in the genus, *Stachyocnemus apicalis* (Dallas) and *S. cinereus* Fracker. Differences between these two are neither great nor consistent. Here we redescribe the genus, synonymize *S. cinereus* with *S. apicalis*, and redescribe the species.

Methods and Materials

In addition to the holotype of *Stachyocnemus apicalis* and the type series of *Stachyocnemus cinereus* (holotype ♂, Ft. Collins, CO; allotype ♀, La Salle, CO; paratype ♂, Gunnison, CO), we have examined more than 80 specimens from the full range of the genus. Specimens were examined in more detail from New Mexico (Socorro Co.), Texas (Brazos Co.), Connecticut (Barkhamsted, Litchfield Co. [new state record]), Oaxaca, Mexico, and Havana, Cuba [new country record]. These more closely studied specimens are in the collection of CWS or the University of Connecticut Insect Collection (the Cuban specimen is from The Natural History Museum, London). The type material of *S. cinereus* was borrowed from the National Museum of Natural History, Smithsonian Institution (Washington, D.C.), and the type of *S. apicalis* is from The Natural History Museum (London).

Genus *Stachyocnemus* Stål

Stachyocnemus Stål, 1870, p. 215 (orig. description).
Stachyocnemus Stål, 1873, p. 91 (key).
Stachyocnemus; Lethierry and Severin, 1894, p. 113 (cat.).
Stachyocnemis (sic!); Van Duzee, 1906, pp. 386-387 (note).
Stachyocnemis (sic!); Banks, 1910, p. 75 (cat.).
Stachyocnemus; Van Duzee, 1917, p. 115 (cat.).

Stachyocnemus; Fracker, 1918, p. 275 (description).

Stachyocnemus; Malloch, 1921, p. 54 (trichobothria).

Stachyocnemus; Torre-Bueno, 1925, p. 28 (ecology and habits).

Stachyocnemus; Blatchley, 1926, pp. 268–269 (description).

Stachyocnemus; Torre-Bueno, 1940, p. 159 (note).

Stachyocnemus; Schaefer, 1972a, p. 139 (loss of scent gland apparatus).

Stachyocnemus; Schaefer, 1972b, p. 817 (loss of scent-gland apparatus, and ecology and biology).

Stachyocnemus; Slater, 1974, pp. 162–163 (relationships).

Stachyocnemus; Schaefer, 1980, pp. 116–118 (male genital capsule).

Head: Dorsum ranging from almost flat to convex, declivent; about as wide as long; paraclypei free of and projecting beyond clypeus, pointed; setae on dorsum of head dark, scattered, conspicuous; interocellar distance approximately equal to distance between ocellus and eye. Antenna short, about half as long as body, with conspicuous dark scattered setae; first antennal segment surpassing apex of head but shorter in total length than head; relative length of segments in ascending order either 2, 3, 4, 1 or 3, 2, 4, 1. Rostrum reaching mesosternum; fourth segment only slightly longer than third; relative lengths of segments in ascending order either 3, 4, 1, 2 or 3, 4, 2, 1. *Thorax:* Pronotum wider than long; anterior one-third not arising above level of collar; posterior corners distinctly acuminate but not drawn out into spines; with small tooth in middle of posterior margin; usually a darker triangle evident medially on pronotum with apex directed anteriorly; setae dark, scattered, conspicuous; pleural areas of meso- and metathorax minutely granulate. Scent gland orifice small, inconspicuous, peritreme absent. Scutellum longer than wide; apex more or less truncate; apex and edges slightly raised. Corium punctate; apical portion not extending along costal edge of membrane as in other alydines. Hind coxae widely separated; hind femur weakly incrassate, armed on posterior surface with two rows of spines; hind tibia straight, without apical spine, but armed with two parallel rows of spines, one row larger and more prominent; tibial setae present, longer than spines; first hind tarsal segment almost twice as long as combined length of second and third segments. *Abdomen:* Robust; sternum IV longer than other sterna. *Male genital capsule and paramere:* Fig. 1.

Type species: *Alydus apicalis* Dallas.

Stachyocnemus is easily distinguished from other North American and Mexican alydines by this combination of characters: small size (about three-quarters the size of the others); lack of an apical hind-tibial spine, of a costal stridulitrum, and of a metathoracic scent gland peritreme; hind tibia with two rows of spines; and fourth antennal segment shorter than first. Among the Alydinae, only *Stachyocnemus*, *Euthetus* Dallas, and *Tollius* Stål lack the scent gland peritreme; *Euthetus* is Old World tropical, and the New World *Tollius* lacks the two rows of spines on the hind tibia.

The generic relationships of *Stachyocnemus* are unclear. Slater (1974) suggested the genus was "more closely related to Palearctic than to Neotropical genera" (p. 162). Torre Bueno (1940) separated *Stachyocnemus* and *Tollius* as a group of North American alydines distinct from *Alydus* Fabricius, *Megalotomus* Fieber, and *Hyalymenus* Amyot et Serville. *Stachyocnemus* and *Tollius* do somewhat resemble each other in habitus, both being smaller than members of the second group, and both having obsolescent metathoracic scent gland apparatuses. However, *Tollius* has, and *Stachyocnemus* lacks, the stridulitrum-plectrum complex and the genital capsule's surcapsular spines, apomorphies possessed also by *Alydus* and *Megalotomus* but not *Hyalymenus* (Schaefer et al. 1989). And *Hyalymenus* and *Stachyocnemus* both have

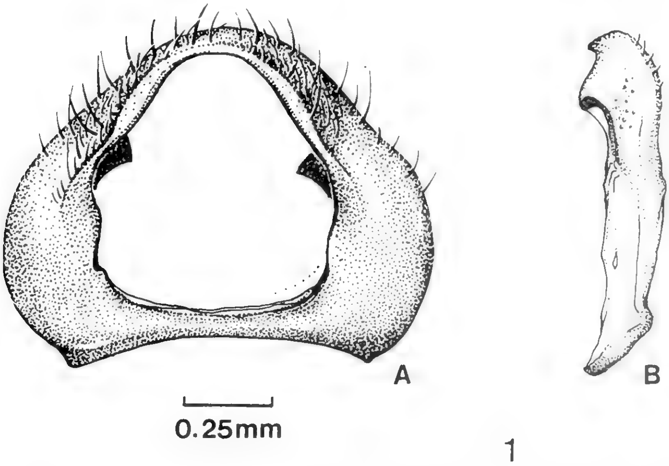

Fig. 1. *Stachyocnemus apicalis*; Texas. Genital capsule (A) and paramere (B) of male. (Note: capsules and parameres of New Mexico and Connecticut specimens, and of the holotype of *S. cinereus*, are identical to those figured here.)

a supporting spur extending from the genital capsule's infolded ventral rim to the cuplike sclerite (Schaefer 1980).

In a cladistic analysis of alydid genera, Li and Zheng (1993) place *Riptortus* + *Camptopus* as the sister clade of *Stachyocnemus*. Their text states that the three genera share three apomorphies. However, their matrix indicates that *Riptortus* Stål lacks one of these apomorphies and that *Camptopus* Amyot et Serville lacks another. Thus *Stachyocnemus* shares one apomorphy with both (vesica of aedeagus spiralled), one with *Riptortus* (apex of paramere hooked), and one apomorphy with *Camptopus* (a conjunctival character). Yet *Stachyocnemus* shares all these apomorphies with *Mirperus*, considered by Li and Zheng (1993) the sister clade of *Stachyocnemus* + (*Riptortus* + *Camptopus*). Also, *Stachyocnemus* shares two exclusive apomorphies with *Tollius* (absence of metathoracic scent gland peritreme, metasternum broad).

Riptortus occurs in the Old World tropics; a few species reach into the southern temperate regions of Asia. *Camptopus* appears to have a rather restricted range in eastern and southern Europe; and *Mirperus* Stål is Afrotropical. The range of none of these genera supports a sister-group relationship with *Stachyocnemus*, which ranges through the Nearctic south of Canada and into Mexico and Cuba. *Tollius* is closer to *Stachyocnemus* than are other alydid genera, but the evidence is equivocal and the relationship weak. We agree with Fracker (1918) and Schaffner (1964), that *Stachyocnemus* has no close relatives among the North American or Mexican alydines or among any others.

Schaffner (1964) noted that the *Stachyocnemus* male's genital capsule is "unique" and that it is "suggestive of" that of the Coreinae (p. 96); later (1979, letter to CWS) he wrote that "the margin of the genital capsule . . . is higher and consequently more like that of the Coreinae." In addition, Schaefer (1980) showed that the capsules of both groups have a fused cuplike sclerite and median projection, and an entire (not excised) ventral rim. Of these three features, the last is certainly plesiomorphic, the second (although advanced) occurs widely elsewhere, and the first is both plesiomorphic and common. These similarities do not indicate a relationship of *Stachyocnemus* and the Coreinae.

The known range of the genus is from

Connecticut (this paper) south into Florida and west into Alberta (Froeschner 1988), through Mexico as far south and east as Oaxaca (Brailovsky and Flores 1979), and also into Cuba (this paper).

These insects feed upon seeds of a low-lying legume (M. H. Sweet, personal communication), and are not predaceous, as Vestal (1913) suggested.

In 1918 Fracker described a new "variety" of *Stachyocnemus apicalis* (Dallas), hitherto the only species in the genus. He characterized *S. apicalis* var. *cinereus* as paler than the nominate form, more western, and differing in several structural features. Influenced by Fracker's descriptions and figures, Torre Bueno (1940) raised var. *cinereus* to species rank; later (1941) he gave the range of each as overlapping in the Rocky Mountain states.

After examining 78 specimens of both forms, Schaffner (1964) concluded "There is a great range of variability among specimens of the same series" and "Characters given by Fracker (1918) and Torre-Bueno (1950[sic]) for separation of varietal or specific designations are of no value"; and he synonymized *S. cinereus* Fracker with *S. apicalis* (Dallas). This conclusion, and the synonymy, were never published.

Fracker (1918) distinguished *S. apicalis* from the variety *cinereus* on the basis of four characteristics:

- Juga projecting, or not, from tylus. The clypeus (tylus) and paraclypei (juga) are the same in all specimens we have examined, including the holotype of the *S. apicalis* (Florida), a male from Cuba, the type series of *S. cinereus* (Colorado), and specimens from nearby New Mexico. In the New Mexican specimens, however, a heavy white pubescence (which is darker and less dense in all other specimens) obscures the clypeus and paraclypei and thus their relationship (not so in the *S. cinereus* type series or the Cuban specimen).
- Body color of *S. cinereus* gray-flavescent, with fine gray pubescence; *S. apicalis* black with ferrugineous markings and little or no gray pubescence. The former is true (see above) of the New Mexico specimens; the others are reddish brown (Texas, Oaxaca) or dark brown (Connecticut). Oddly, the *S. cinereus* type series itself is pale brown to tan, and the holotype of *S. apicalis* is brown to dark brown.
- Head depressed (*S. apicalis*) or not (*S. cinereus*). The head is equally depressed in all specimens.
- Medial tooth on pronotum's posterior border smaller in *S. apicalis* than in *S. cinereus*; this is true of both holotypes. This tooth in the Connecticut specimens and the one from Cuba is smaller than in the others. But the Oaxaca specimens, where the tooth is larger, otherwise agree with Fracker's description of *S. apicalis*, not of *S. cinereus*; and the tooth of the New Mexico specimens is smaller than that of the *S. cinereus* type series. This character cuts across Fracker's descriptions of the two species.

In addition, the pre-antennal head of the members of the *S. cinereus* type series, and of the *S. apicalis* holotype, is broader—the paraclypei narrow less sharply—than is the head of the Connecticut and New Mexico specimens. But specimens from other parts of the United States, including Texas, and from Oaxaca and Cuba, are intermediate.

The New Mexico and Texas specimens are smaller than the others, as are the male holotype and paratype of *S. cinereus* and the male holotype of *S. apicalis*. But the width-length ratios (width across humeri and total body length) are not greatly different: New Mexico, 0.273; Connecticut, 0.310; Oaxaca, 0.300; Texas, 0.290; *S. cinereus* holotype, 0.298; allotype, 0.269; paratype, 0.300; *S. apicalis* holotype, 0.293; Cuba 0.301. Similarly, the width-length ratios of the genital capsules from the Texas (0.800), Connecticut (0.820), and New Mexico (0.833) specimens differ but little.

The width-length ratio of the *S. cinereus* holotype, however, is 1.0, but in structure it is identical with that of a Texas specimen (Fig. 1). The overall size differences therefore appear to have resulted from changes in absolute, not in relative, growth and are therefore unlikely to be genetic.

The only character which appears to separate the two forms is the paler body color and whitish pubescence of *S. cinereus*. This is insufficient to warrant distinguishing the two as species, especially as the genital capsule and parameres of all specimens are identical (Fig. 1).

Moreover, the distributions do more than overlap; *Stachyocnemus cinereus* is an island in a sea of *S. apicalis*. Fracker (1918) lists the former from Colorado (type locality), Indiana, Montana, and Arizona; and we have specimens that fit this description from New Mexico. *S. apicalis* is found throughout North America (Froeschner 1988) and Brailovsky and Flores (1979) list it through Mexico to Oaxaca; these latter authors' description of their specimens fits *S. apicalis* better than it does *S. cinereus*.

For all these reasons, we agree with Schaffner's unpublished dissertation (1964), and synonymize *Stachyocnemus cinereus* Fracker with *S. apicalis* (Dallas).

Stachyocnemus apicalis (Dallas)

Alydus apicalis Dallas, 1852, p. 479 (orig. description).

Stachyocnemus apicalis; Stål, 1870, p. 215 (cat.).

Alydus apicalis; Walker, 1871, p. 159 (cat.).

Alydus apicalis; Walker, 1873, p. 42 (cat.).

Stachyocnemus apicalis; Uhler, 1886, p. 12 (list).

Stachyocnemis apicalis; Lethierry and Severin, 1894, p. 112 (cat.).

Stachyocnemus apicalis; Heidemann, 1902a, p. 32 (distribution).

Stachyocnemus apicalis; Heidemann, 1902b p. 81 (distribution).

Stachyocnemus apicalis; Van Duzee, 1909, p. 160 (note).

Stachyocnemis (sic!) *apicalis*; Banks, 1910, p. 75 (cat.).

Stachyocnemus apicalis; Fracker, 1918, pp. 275–276, pl. 11, figs. 13, 14 (description, adult fig.).

Stachyocnemus apicalis; var. *apicalis*; Fracker, 1918, p. 276, pl. 11, fig. 13 (note, adult fig.).

Stachyocnemus apicalis; var. *cinereus* Fracker, 1918, p. 276, pl. 11, fig. 14 (orig. description, adult fig.) (**new synonymy**).

Stachiocnemus (sic!) *apicalis*; Johnson and Ledig, 1918, p. 4 (list).

Stachyocnemus apicalis; Malloch, 1921, p. 81, fig. 16 (trichobothria, fig.).

Stachyocnemus apicalis; Blatchley, 1926, pp. 269–270 (description, note).

Stachyocnemus apicalis var. *cinereus*; Blatchley, 1926, p. 270 (note).

Stachyocnemus apicalis; Leonard, 1928, p. 88 (list).

Stachyocnemus apicalis; Torre-Bueno, 1940, p. 159 (note).

Stachyocnemus cinereus; Torre-Bueno, 1940, p. 159 (new status).

Stachyocnemus apicalis; Torre-Bueno, 1941 p. 88 (distribution).

Stachyocnemus cinereus; Torre-Bueno, 1942, p. 180 (distribution).

Stachyocnemus apicalis; Sherman, 1948, p. 16 (distribution).

Stachyocnemis (sic!) *apicalis*; Strickland, 1953, p. 196 (distribution).

Stachyocnemus apicalis; Froeschner, 1988, p. 8 (cat., distribution).

Stachyocnemus cinereus; Froeschner, 1988, p. 8 (cat., distribution).

Type data: Holotype, male, "St. John's Bluff, East Florida." United States. On deposit in The Natural History Museum, London.

Description: Pale to dark brown, paler specimens more heavily beset with pale recumbent setae. Entire insect except for fourth antennal segment and tarsal segments usually with conspicuous, decumbent, flat almost scale-like microtrichia, these sometimes silvery under high illumination. Side of head with pale line running from gula onto lateral edge of pronotum. Pronotum with large triangular region medially, this lightly setose and therefore appearing darker than lateral regions, these more heavily beset with pale setae; collar yellow. Corium sometimes speckled or lightly mottled with darker brown; if with pale recumbent hairs, these more dense along veins. Membrane pale to dark brown, with dark brown speckling; veins at very base dark brown, rest of membrane pale brown. Legs heavily mottled with brown; spines of femora and tibiae dark brown. Abdominal venter pale to dark brown, often paler medially, heavily speckled with brown or reddish spots; with erect brown setae interspersed among white recumbent setae, venter not heavily hirsute; each segment laterally with large pale spot surrounding spiracle, and with another sublateral spot anterior to trichobothria (latter spots sometimes obscure or poorly defined). Total length: 7–9 mm.

NEW DISTRIBUTIONAL RECORDS

CUBA: Grillo Ravelo (1989) listed the alydine genera *Burtinus, Hyalymenus*, and *Megalotomus* from Cuba. A male in The Natural History Museum (London) of *Stachyocnemus apicalis* adds a fourth genus to the list. Labels: Havana III. 4.v.12/ AWJ Pomeroy collector/U.S. America A.W.J. Pomeroy. 1919-269/Pres. By Imp. Bur. Ent. [last label pinned face down].

U.S.A., Connecticut: Although *Stachyocnemus apicalis* has been recorded from as close as New York and New Jersey (Froeschner 1988), it has not been listed from Connecticut; we list here two males from Barkhamsted, in the northwestern part of the state, collected in different summer months. Labels: CT: Litchfield Co., Barkhamsted, Farmington River across from Rt 181, June 11, 1991/R. J. Packauskas collector [in collection of C.W.S.]. Second specimen: Barkhamsted nr. Rt. 318, Litchfield Co., CT Aug. 1, 1991, R. J. Packauskas [in Univ. Conn. Insect Collection].

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PARASITOIDS (HYMENOPTERA: BRACONIDAE: APHIDIINAE) OF APHIDS ON BIG SAGEBRUSH (*ARTEMISIA TRIDENTATA* NUTTALL) AND PRAIRIE SAGE (*ARTEMISIA LUDOVICIANA* NUTTALL) IN WASHINGTON STATE

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Abstract.—Parasitoid-aphid associations on big sagebrush, *Artemisia tridentata* Nuttall and prairie sage, *Artemisia ludoviciana* Nuttall in Washington State are determined, and the parasitoid species are reviewed and keyed. Two new species of aphidiine parasitoids are described and illustrated: **Praon artemisicola Pike and Starý**, n. sp. (hosts: *Epameibaphis atricornis* Gillette & Palmer, *Flabellomicrosiphum* sp. and *Pseudoepameibaphis tridentatae* Wilson; also from mixed populations of *Flabellomicrosiphum knowltoni* Smith, *Obtusicauda filifoliae* Gillette and Palmer, and *Pleotrichophorus* sp. on *A. tridentata*), and **Trioxys artemisiarum Pike and Starý,** n. sp. (host: *Macrosiphoniella ludovicianae* (Oestlund) on *A. ludoviciana*). The sagebrush areas of the region are relatively widespread with mainly indigenous flora; the associated aphids and parasitoids are also indigenous and constitute a relatively rich diversity of species. Twelve species of sagebrush and prairie sage aphid-parasitoids are known from the region.

Key Words: sagebrush, *Artemisia*, aphids, parasitoids, *Praon artemisicola* n. sp., *Trioxys artemisiarum* n. sp., biodiversity

Big sagebrush (*Artemisia tridentata* Nuttall) (Fig. 1) occurs across vast reaches and fragmented tracts of land within the interior areas of the Pacific Northwest where precipitation is commonly less than 50 cm per year. Big sagebrush is indigenous to the region and somewhat competitive with perennial grasses (Whitson et al. 1991) and other plants. The sagebrush communities commonly adjoin agricultural lands, sometimes dryland grain fields, sometimes irrigated fields. Prairie sage (*Artemisia ludoviciana* Nuttall) is also common in the region, but restricted more to streambanks and flood plains.

A recent review of Pacific Northwest aphidiine parasitoids by the authors (Pike et al. 1996) indicated a number of plant communities in which more detailed research should be undertaken, including sagebrush. Further, a catalog by Marsh (1979) of North American aphidiines showed little information for the Northwest. We theorized that sagebrush or sagebrush and other plants in the sagebrush ecosystem, especially in undisturbed settings, might harbor parasitoids (Fig. 2) useful against aphids in adjoining crops or serve as a stable source for such. Distinguishing tritrophic associations (parasitoid-aphid-plant) in ecosystems or agro-

Figs. 1–2. 1, Big sagebrush landscape, WA, Benton Co., Rattlesnake Hills, 1-VI-96 (photo by L. C. Wright, Res. Tech. Supervisor, Washington State University, Prosser, WA). 2, *Obtusicauda coweni* aphids on big sagebrush parasitized by *Lysiphlebus utahensis*, WA, Yakima Co., near Wenas Lake, 30-V-96 (photo by K. S. Pike).

ecosystems constitute one of the first steps needed in biodiversity research, and for advancing the use of or enhancing aphid biological controls. The purpose of this research was to define the diversity of aphidiine parasitoids and their associated aphid-hosts on big sagebrush and prairie sage, describe new species as appropriate, and present a key to the parasitoids of big sagebrush and prairie sage aphids.

MATERIALS AND METHODS

Big sagebrush and prairie sage were extensively sampled for aphids and aphid-parasitoids across eastern Washington, covering Asotin, Benton, Douglas, Franklin, Klickitat, Kittitas, and Yakima counties. A total of 130 samples was taken over three years (1994–96), and 831 parasitoids were reared and examined. The collected live aphids from which parasitoids were reared, were held in semi-transparent plastic containers (300 ml, 10 cm dia × 4 cm ht or 3500 ml, 18 cm dia × 13 cm ht) on clipped foliage at laboratory temperatures of 20 ± 3°C for 25–30 days to provide time for parasitoids to develop; adults generally emerged within 10 days.

New descriptions were based on whole dry and dissected slide-mounted specimens evaluated under microscope at 40 to 600×. Measurements were recorded in millimeters. Holotypes were dry-mounted on paper tabs and pinned. Descriptive terminology is after Huber and Sharkey (1993). Holotypes are deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM).

REVIEW OF PARASITOID SPECIES OF BIG SAGEBRUSH (BS) AND PRAIRIE SAGE (PS) APHIDS

Parasitoid species are listed alphabetically. References, if any, are listed at the end of each record of aphid host, location, and date of collection. All aphids were collected and identified by the authors, unless otherwise indicated. Numbers in parentheses represent authors' codes of voucher specimens (aphid-parasitoids) in Washington State University (WSU)-Prosser collections.

Aphidius polygonaphis Fitch, all from aphids on PS: USA, WA, Yakima Co., Yakama Indian Res., Yakima Chief Rd., 16-V-96, from *Macrosiphoniella ludovicianae* and *Pleotrichophorus* sp. (96G053), Mabton Rd., 25-IV-96 (96K004), and Lower Mill Cr. Rd., 25-V-96, (96K054) from *Macrosiphoniella ludovicianae.*

Binodoxys coruscanigrans (Gahan): USA, WA, Yakima Co., Mabton Grade, 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* on BS (96G068, 96G115).

Binodoxys clydesmithi Pike & Starý, all from aphids on BS: USA, WA, Franklin Co., Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Kittitas Co., Lost Lake, 7-VII-94, from *Obtusicauda coweni* and *Zyxaphis* sp. (det. G. Remaudière) (94K042) (Pike et al. 1996).

Ephedrus californicus Baker, all from aphids on BS unless indicated otherwise: USA, WA, Klickitat Co., Roosevelt, 9 & 24-IV-96, from *Obtusicauda* sp. (96G011, 96G015), 16-IV-96, from *Obtusicauda artemisiphila* (96G012); Yakima Co., Mabton Grade, 14-V-96, from *Obtusicauda coweni* (96G026); Yakama Indian Res., Mabton Rd., 25-IV-96, from *Macrosiphoniella* nr. *ludovicianae* on PS (96K004), 16-V-96, from *Macrosiphoniella ludovicianae* and *Pleotrichophorus pseudoglandulosus* on PS (96G049).

Lysaphidus adelocarinus (Smith), all from aphids on BS: USA, WA, Benton Co., Arid Lands Ecol. Reserve, Rattlesnake Springs, 10-V-96, from *Epameibaphis atricornis*, *Microsiphoniella* sp., *Obtusicauda* sp. and *Pleotrichophorus* spp. (95G032), Snively Springs, 19-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G072), near Rothrock and Pearl Rds., 29-VI-95, from *Flabellomicrosiphum knowltoni,* *Pseudoepameibaphis tridentatae* and *Zyxaphis canae* (95G280); Franklin Co., Juniper Dunes Wilderness, 23-V-95, from *Flabellomicrosiphum knowltoni* and *Microsiphoniella acophorum* (95G088, 95G089), Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Kittitas Co., Ellensburg, 20-VI-95, from *Pseudoepameibaphis tridentatae* (95G198), Taneum Rd., 11-IX-95, from *Pleotrichophorus* sp., *Pseudoepameibaphis glauca*, and *Zyxaphis* sp. (95G586); Klickitat Co., Alderdale Cr. & Columbia River, 28-IV-95, from *Pleotrichophorus* sp. (95G012), 2-IV-96, from *Flabellomicrosiphum tridentatae*, *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* (96G007), near Alderdale, 9-V-95, from *Pleotrichophorus* sp. (95G026), *Flabellomicrosiphum* sp., *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G027), 11-VII-95, from *Flabellomicrosiphum tridentatae* and *Pseudoepameibaphis essigi* (95G345), Roosevelt, 24-IV-96, from *Obtusicauda* sp. (96G015); Yakima Co., Moxee Hwy 24, 15-V-95, from *Epameibaphis atricornis* and *Flabellomicrosiphum knowltoni* (95G066), Plank Rd., 15-V-95, from *Pseudoepameibaphis tridentatae* (95G069), Fort Simcoe, 30-V-95, from *Flabellomicrosiphum knowltoni* and *Pseudoepameibaphis tridentatae* (95G091), Yakama Indian Res., near White Swan, 6-VI-95, from *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G110), Yakama Indian Res. near Satus, 16-V-96, from *Epameibaphis atricornis*, *Flabellomicrosiphum* sp., and *Pseudoepameibaphis tridentatae* (96G062), Yakama Indian Res., Mabton Rd., 25-IV-96, from *Obtusicauda* sp. (96K005), Yakima Firing Range, 24-VII-95, from *Obtusicauda* sp., and *Pseudoepameibaphis tridentatae* (95G370).

Lysaphidus ramithyrus (Smith): USA, WA, Kittitas Co., Taneum Rd, 11-IX-95, from *Pleotrichophorus* sp. and *Zyxaphis* sp. on BS (95G585).

Lysiphlebus utahensis (Smith), all from aphids on BS: USA, WA, Franklin Co., Kahlotus Hwy, Neff Farm, 28-V-96, from *Obtusicauda artemisicola* (96G096); Klickitat Co., near Roosevelt, 2 & 9-IV-96, from *Obtusicauda filifoliae* (96G009) and *Obtusicauda* sp. (96G011); Yakima Co., Mabton Grade, 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* (96G068, 96G115, 96G122).

Praon artemisaphis Smith, all from aphids on BS: USA, WA, Klickitat Co., Roosevelt, 9-IV-96, from *Obtusicauda* sp. (96G011); Yakima Co., Mabton Grade, 14 & 23-V-96, and near Wenas Lake, 30-V-96, from *Obtusicauda coweni* (96G026, 96G068, 96G115), Yakama Indian Res., Mabton Rd., 25-IV-96, from *Flabellomicrosiphum knowltoni* and *Pleotrichophorus* sp. (96K003), from *Obtusicauda* sp. (96K005).

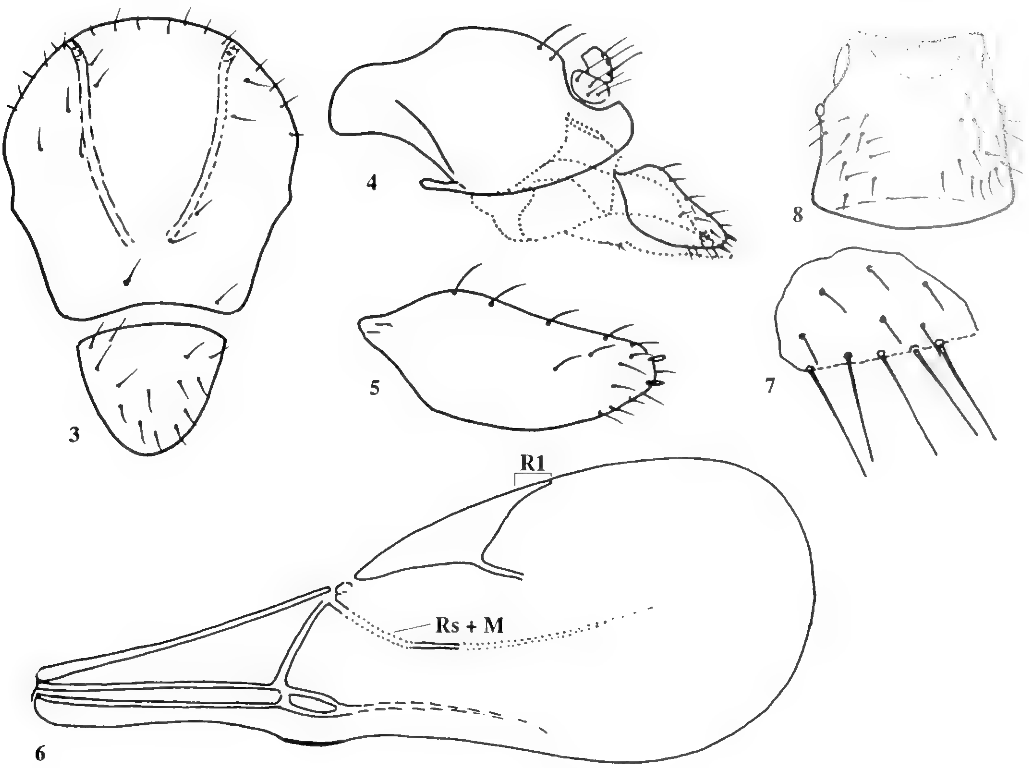
Praon artemisicola Pike & Starý, new species

(Figs. 3–8)

Diagnosis.—Following the key by Johnson (1987), the new species has several characters (radial sector length, distal abscissa of R1 length, and stigma width) in common with *P. artemisaphis* Smith, but differs in the number of antennal segments (13–14) and status of the m-cu vein (almost to completely effaced).

Etymology.—The new species name is derived from its association with big sagebrush, *Artemisia tridentata*.

Description.—*Female:* Head. Malar space equal to ⅙ of eye length. Face glabrous, with a row of setae along orbits. Antenna 13–14 segmented, short, filiform, as long as head, mesosoma and basal third of metasoma together. Flagellomere 1 (= F_1) 4× as long as wide, with sparse long oblique setae slightly longer than half segment diameter, no longitudinal placodes. F_2 3× as long as wide, with one placode. Middle flagellomeres 2.5× as long as wide, with sparse oblique setae subequal to seg-



Figs. 3–8. *Praon artemisicola* (illustrations not to equal scale). 3, Mesonotum. 4, Genitalia. 5, Ovipositor sheath. 6, Forewing. 7, Forewing lower margin close-up. 8, Metasomal tergum 1. Abbreviations: R1, radial abscissa (= metacarpus); Rs + M, wing vein.

ment diameter. Preapical flagellomere as wide as middle flagellomeres.

Mesosoma. Mesonotum (Fig. 3) with all lobes glabrous, with a few scattered setae along the notauli. Propodeum smooth.

Forewing (Figs. 6–7). Stigma 4× as long as wide; distal abscissa of R1 (= metacarpus) relatively short, equal to ⅐ of stigma length. Radial sector equal to stigma width; median vein discolored in the proximal portion; m-cu vein effaced except sometimes for a short discolored proximal stub. Lower marginal setae (Fig. 7) 5× as long as surface setae.

Legs. Hind femur with sparse semi-erect setae that are slightly longer than half segment diameter.

Metasoma. Metasomal tergum 1 (Fig. 8) square, with groups of setae close to hind corners.

Genitalia (Figs. 4–5).

Coloration. Head dark brown, mandibles brown, palpi light brown. Antenna brown, pedicel and basal ⅔ of F_1 yellow to light brown with lighter basal ring. Mesosoma dark brown. Wings subhyaline, venation light brown. Fore leg yellow brown to brown, middle and hind legs brown, base of tibiae lighter. Metasoma brown, tergum 1 light brown. Ovipositor sheath brown.

Body length about 1.6–1.8 mm.

Male: Antenna 16–17 segmented, long, subequal to body length. Concolorous, somewhat darker than female. Antenna dark brown, narrow apex of pedicel and a narrow basal ring of F_1 light brown. Metasoma brown, tergum 1 dark brown.

Holotype [♀].—USA, WA, Yakima Co., Alderdale and Glade Rd., 9-V-95, reared from (mixed aphids) *Epameibaphis atricor-*

nis Gillette & Palmer, *Flabellomicrosiphum* sp., and *Pseudoepameibaphis tridentatae* (Wilson) taken from big sagebrush, *Artemisia tridentata* Nuttall, coll. G. Graf, sample no. 95G030. Deposited in USNM.

Paratypes.—reared from aphids on big sagebrush, *Artemisia tridentata*: USA, WA, Benton Co., Crosby Rd. 1-V-95, from *Pseudoepameibaphis tridentatae* (95G015, 3 ♂), Hwy 240 and Horn Rapids, 12-V-95, from *Pseudoepameibaphis tridentatae* (95G041, 1 ♀); Klickitat Co., Alderdale Rd., 9-V-95, from *Flabellomicrosiphum* sp., *Pseudoepameibaphis tridentatae*, and *Obtusicauda filifoliae* (95G027, 1 ♀), near Alderdale, 9-V-95, from *Pleotrichophorus* sp. and *Pseudoepameibaphis tridentatae* (95G028, 1 ♀), Alderdale Rd., 5mi N of Hwy 14, 12-V-95, from *Epameibaphis atricornis* (95G037, 1 ♀); Yakima Co., Alderdale and Glade Rd., 9-V-95, from *Epameibaphis atricornis*, *Flabellomicrosiphum* sp. and *Pseudoepameibaphis tridentatae* (95G030, 2 ♀), Moxee Hwy, 15-V-95, from *Epameibaphis atricornis*, *Flabellomicrosiphum knowltoni* (95G066, 1 ♀, 2 ♂), Plank Rd., 15-V-95, from *Pseudoepameibaphis tridentatae* (95G069, 2 ♂). Material deposited in part in the Washington State University Collection, James Museum, Pullman, WA; the Washington State University-Prosser Collection, and the collection of P. Starý, Česke Budějovice, Czech Republic.

Praon occidentale Baker: USA, WA, Yakima Co., Yakama Indian Res., Mabton Rd., 25-IV-96, from *Macrosiphoniella ludovicianae* on PS (96K004).

Trioxys artemisiarum Pike & Starý, new species

(Figs. 9–12)

Diagnosis.—Following the key by Smith (1944), the new species has characters in common with *T. bonnevillensis* Smith and *T. infrequens* Smith. *T. bonnevillensis* differs from the new species in having somewhat shorter prongs, four perpendicular setae dorsally, and with oblique setae distinctly longer than prong diameter. *T. infrequens* (based on Smith's 1944 original description) differs from the new species in having prongs fused along basal halves, and flagellomeres approximately equal in length and unusually long. Also, the antenna of the new species is 12-segmented vs. 11-segment in *T. bonnevillensis* and *T. infrequens*.

Etymology.—The new species name is derived from its association with *Artemisia*.

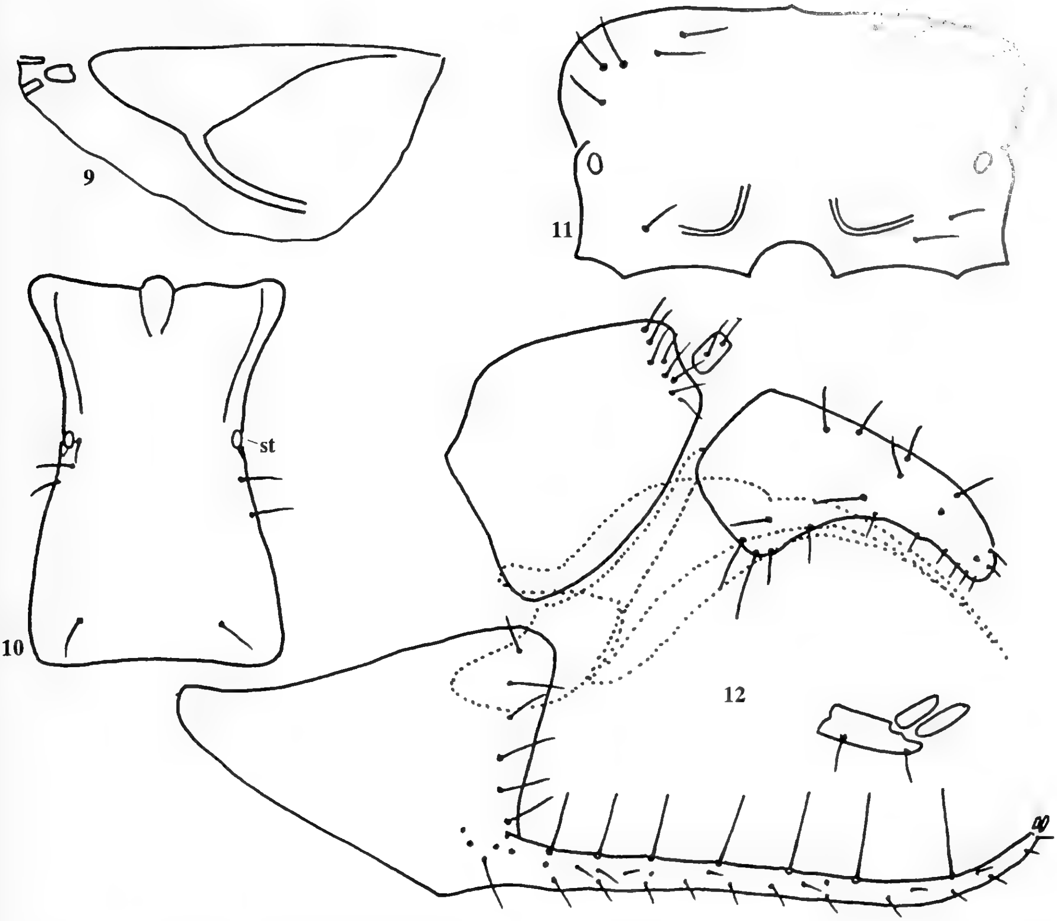
Description. *Female:* Head. Eyes prominent, strongly convergent to clypeus. Malar space equal to ⅙ of eye length. Tentorioocular line equal to ¼ of intertentorial line. Antenna 12-segmented, filiform, reaching to middle of metasoma; middle to apical flagellomeres equal in width, gradually shorter towards apex of flagellum. Second flagellomere (F_2) 3× as long as wide, middle flagellomeres 2.3× as long as wide.

Mesosoma. Mesonotum with simple rows of relatively sparse setae along effaced notauli of disc. Propodeum (Fig. 11) smooth, with two short divergent carinae in distal portion.

Forewing (Fig. 9) stigma triangular, almost 3× greatest width; distal abscissa of R1 (= metacarpus) relatively short, shorter than ⅓ stigma length or distinctly shorter than stigma width. Radial sector short, somewhat longer than stigma width. Hind femur and tibia with adpressed setae.

Metasoma. Metasomal tergum 1 (Fig. 10) somewhat longer than 2× spiracular width, dilating from poorly prominent spiracular tubercles to apex, about 1.5× as wide at apex as across spiracles.

Genitalia (Fig. 12). Ovipositor sheath distinctly claw-shaped. Prongs long and straight except for upward curve at apex, distinctly separated along their length, 7–8 long perpendicular setae on dorsal surface (setae gradually increasing in length towards apex of prong, length 2–3× adjacent prong diameter), numerous shorter oblique setae on ventral surface (length subequal to adjacent prong diameter), sternal base of prongs with a single row of long, longitudinal setae (subequal in length to dorsal se-



Figs. 9–12. *Trioxys artemisiarum* (illustrations not to equal scale). 9, Forewing, in part. 10, Metasomal tergum 1. 11, Propodeum. 12, Genitalia. Abbreviation: st, spiracular tubercle.

tae), and prong apex with two longitudinally dilated setae.

Coloration. Distinctly bicolorous, with some variation. Head yellow; ocellar triangle brown, sometimes brown from frons to vertex. Antenna dark brown, most of scape and pedicel, and whole of F_1 yellow. Mesosoma brown black, sometimes prothorax yellow brown. Tegulae yellow. Wings subhyaline, venation brown. Legs brown, tinge darkest in hind leg; trochanter, base and narrow apex of tibia and tarsomere 1 or most of tarsus yellow. Metasoma distinctly bicolorous, middle part prevalently dark brown; tergum 1 and central spot at tergum 2 light brown. Middle terga sometimes with light lateral spots; apex yellow. Last tergum with central brown spot, apical half of ovipositor sheath brown; sternum and prongs yellow.

Body length 2.3–2.5 mm.

Male: Antenna 14-segmented. Coloration generally dark brown; apex of pedicel and mandibles yellow. Metasomal tergum 1 and base of tergum 2 light brown.

Holotype [♀].—USA, WA, Asotin Co., Heller's Bar, 20-VI-95, reared from *Macrosiphoniella ludovicianae* (Oestlund) taken from big sagebrush, *Artemisia tridentata* Nutall, coll. T. Miller, sample no. 95T146. Deposited in USNM.

Paratypes.—USA, WA, Asotin Co.,

Couse Creek and Heller's Bar, 20-VI-95, from *Macrosiphoniella ludovicianae* on BS (95T126, 2 ♀, 2 ♂; 95T146, 2 ♂), and 18-VII-95 on PS (95T257, 2 ♀, 3 ♂). Deposited in part in the Washington State University Collection, James Museum, Pullman, WA; the Washington State University-Prosser Collection, and the collection of P. Starý, Česke Budějovice, Czech Republic.

Trioxys bonnevillensis Smith, all from aphids on BS unless indicated otherwise: USA, WA, Benton Co., Arid Lands Ecol. Reserve, Rattlesnake Springs, 10 -V-95, from *Epameibaphis atricornis*, *Microsiphoniella* sp., *Obtusicauda* sp., and *Pleotrichophorus* spp. (95G032), 19-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G072), 8-VI-95, *Epameibaphis* sp. and *Pseudoepameibaphis tridentatae* (95G151), Bennett Springs, 2-V-95, from *Epameibaphis atricornis*, *Pleotrichophorus* sp., and *Pseudoepameibaphis tridentatae* (95G018), Hwy 14, 12-V-95, from *Pseudoepameibaphis tridentatae* (95G039), Prosser, 8-VI-95, from *Pseudoepameibaphis tridentatae* (95K032), Rotha Rd, 2-V-95, from *Obtusicauda artemisiae* (95G017), Rothrock Rd., 29-VI-95, from *Flabellomicrosiphum knowltoni*, *Pseudoepameibaphis tridentatae*, and *Zyxaphis canae* (95G280); Douglas Co., Badger Mtn., 13-VII-95, from *Zyxaphis canae* Williams, coll. R. L. Gillespie (95B012); Franklin Co., Juniper Dunes Wilderness, 23-V-95, from *Flabellomicrosiphum tridentatae* and *Microsiphoniella acophorum* (95G088, 95G089); Kittitas Co., Ellensburg, 20-VI-95, from *Pseudoepameibaphis tridentatae* (95G198), Klickitat Co., Alderdale, 11-VII-95, from *Flabellomicrosiphum tridentatae* and *Pseudoepameibaphis essigi* (95G345), Alderdale Cr., 28-IV-95, from *Flabellomicrosiphum tridentatae* (95G013), from *Epameibaphis utahensis*, *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G014), 9-V-95, from *Flabellomicrosiphum* sp., *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G027), 12-V-95, from *Pseudoepameibaphis tridentatae* (95G038), Roosevelt, 2-IV-96, from *Obtusicauda filifoliae* (96G009), 9-IV-96, *Obtusicauda* sp. (96G011), 16-IV-96, from *Obtusicauda artemisiphila* (96G012); Yakima Co., Hwy 82, 12-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G043), 12-V-95, from *Pseudoepameibaphis tridentatae* (95G044), Moxee Hwy, 15-V-95, from *Epameibaphis atricornis* and *Flabellomicrosiphum knowltoni* (95G066), Hwy 82, 15-V-95, from *Epameibaphis atricornis* and *Pseudoepameibaphis tridentatae* (95G067), Fort Simcoe, 30-V-95, from *Flabellomicrosiphum knowltoni* and *Pseudoepameibaphis tridentatae* (95G091), White Swan, 6-6-95, from *Obtusicauda filifoliae* and *Pseudoepameibaphis tridentatae* (95G110), Yakima Firing Range, 24-VII-95, from *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* (95G370), Yakama Indian Res., Chief Rd, 25-IV-96, from *Obtusicauda* sp. (96K005), from *Obtusicauda* sp. and *Pseudoepameibaphis tridentatae* on PS (96G020), Yakama Indian Res. near Satus, 16-V-96, from *Epameibaphis atricornis*, *Pseudoepameibaphis tridentatae* and *Flabellomicrosiphum* sp. (96G062).

KEY TO PARASITOID SPECIES (FEMALES) REARED FROM APHIDS ON *ARTEMISIA* SPP. IN EASTERN WASHINGTON STATE

1. Forewing Rs + M vein present, sometimes more or less colorless, but distinct in fore part (Figs. 6, 14, 22, 23) 2
– Forewing Rs + M vein absent (Figs. 13, 25) 5

2(1). Forewing 1R1 and 1 + 2Rs cells separate; r-m vein present (Fig. 14) . . . .*Ephedrus californicus* Baker
– Forewing 1R1 and 1 + Rs confluent; r-m vein absent (*Praon*) (Figs. 6, 22, 23) 3

3(2). Forewing m-cu vein present (Figs. 22, 23); antenna 16–18 segmented 4
– Forewing m-cu vein absent (Fig. 6); anten-

na 13–14 segmented . . . . *Praon artemisicola* Pike & Starý, n. sp.

4(3). Forewing distal abscissa of R1 (= metacarpus) and radial sector short, equal to width of stigma (Fig. 22); antenna 16–17 segmented . . . . . . *Praon artemisaphis* Smith

– Forewing distal abscissa of R1 and radial sector long, at least 1.5–2.0 times longer than width of stigma (Fig. 23); antenna 17–18 segmented . . . . . *Praon occidentale* Baker

5(1). Forewing r-m vein present (Figs. 13, 24, 25); last abdominal sternite simple, without prongs; ovipositor sheath slightly curved upwards (Figs. 16, 17, 29) 6

– Forewing r-m vein absent (Figs. 27, 28); last abdominal sternite with fork-like accessory prong; ovipositor sheath curved downward (Figs. 12, 30, 32, 34) 9

6(5). Forewing M + m-cu vein complete (Fig. 13) . . . . *Aphidius polygonaphis* Fitch

– Forewing M + m-cu vein incomplete (Fig. 25) 7

7(6). Propodeum with more or less distinct areola or at least carinae (Figs. 19–20); metasomal tergum 1 somewhat parallel-sided (Fig. 21) (*Lysaphidus*) 8

– Propodeum smooth (Fig. 18); metasomal tergum 1 somewhat triangular, distinctly enlarged at apex (Fig. 15) . . . . *Lysiphlebus utahensis* (Smith)

8(7). Propodeum with two divergent carinae in distal portion (length of carinae variable) (Fig. 20) . . *Lysaphidus adelocarinus* (Smith)

– Propodeum areolated, with small central pentagonal areola (size and shape variable) (Fig. 19) . . . . *Lysaphidus ramithyrus* (Smith)

9(5). Metasomal tergum 1 with spiracular and secondary tubercles (Fig. 26) 10

– Metasomal tergum 1 with spiracular tubercles only (Figs. 10, 31) 11

10(9). Lower apical part of metasoma yellow, prongs dark; spiracular and secondary tubercles of metasomal tergum 1 of equal size, distinctly separated from each other; prongs feeble, with 4–5 long setae on dorsal surface in basal portion (Fig. 33); ovipositor sheath broad in basal two-thirds, almost claw-shaped (Fig. 32) . . . . *Binodoxys coruscanigrans* (Gahan)

– Lower apical part of metasoma brown, concolorus with remaining metasoma, prongs dark brown; spiracular and secondary tubercles of metasomal tergum 1 closely spaced, secondary tubercles slightly greater than spiracular tubercles (Fig. 26); ovipositor sheath not claw-shaped, comparatively narrow at base (Fig. 30); prongs strong, with 7 long setae on dorsal surface (Fig. 30); stigma length 3x width (Fig. 28) . . . . *Binodoxys clydesmithi* Pike & Starý

11(9). Prongs of last metasomal sternum short, arcuate, each bearing 4 long perpendicular setae on dorsal surface (Fig. 34); radial sector shorter than stigma width (Fig. 27) . . . . *Trioxys bonnevillensis* Smith

– Prongs of last metasomal sternum long, straight, with apices curved upward, each bearing 7–8 perpendicular setae on dorsal surface (Fig. 12); radial sector longer than stigma width (Fig. 9) . . . . *Trioxys artemisiarum* Pike & Starý, n. sp.

APHID-PARASITOID-PLANT ASSOCIATIONS LISTING

(BS, big sagebrush; PS, prairie sage. *, parasitoid reared from a collection of mixed aphids; specific association shown considered valid by authors)

Epameibaphis atricornis Gillette & Palmer
- **Lysaphidus adelocarinus* (BS)
- **Praon artemisicola* (BS)
- **Trioxys bonnevillensis* (BS)

Epameibaphis utahensis Knowlton & Smith
- **Trioxys bonnevillensis* (BS)

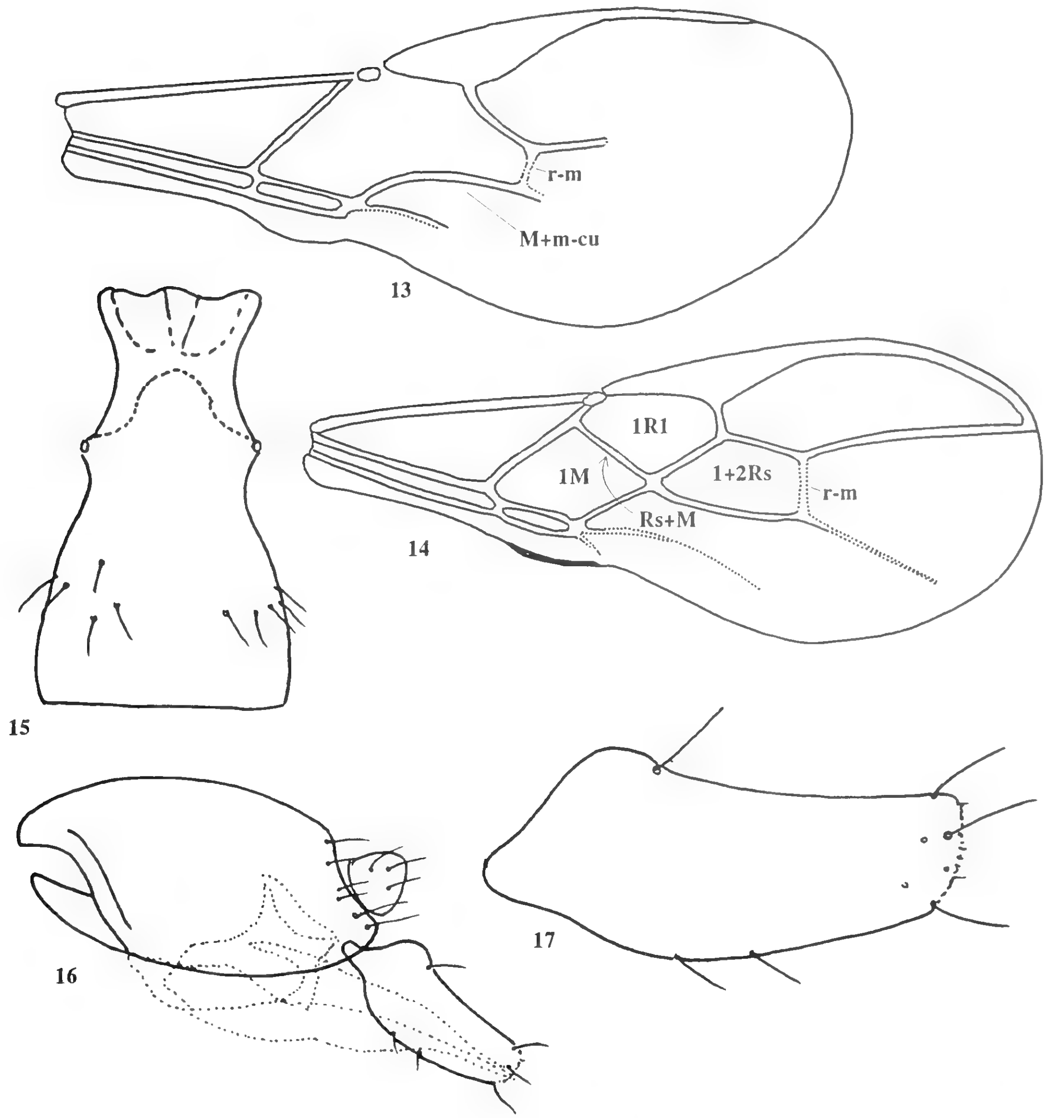
Flabellomicrosiphum knowltoni Smith
- **Lysaphidus adelocarinus* (BS)
- *Praon artemisaphis* (BS)
- **Praon artemisicola* (BS)
- **Trioxys bonnevillensis* (BS)

Flabellomicrosiphum tridentatae (Wilson)
- **Lysaphidus adelocarinus* (BS)
- **Trioxys bonnevillensis* (BS)

Flabellomicrosiphum sp.
- **Lysaphidus adelocarinus* (BS)
- **Praon artemisicola* (BS)
- **Trioxys bonnevillensis* (BS)

Macrosiphoniella ludovicianae (Oestlund)
- **Aphidius polygonaphis* (PS)
- *Ephedrus californicus* (PS)
- **Praon occidentale* (PS)
- **Trioxys artemisiarum* (BS)

Microsiphoniella acophorum (Smith & Knowlton)
- **Lysaphidus adelocarinus* (BS)



Figs. 13–17. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 13, *Aphidius polygonaphis*, forewing. 14, *Ephedrus californicus*, forewing. 15–17, *Lysiphlebus utahensis*. 15, Metasomal tergum 1. 16, Genitalia. 17, Ovipositor sheath. Abbreviations: M + m-cu, Rs + M and r-m are wing veins; 1M, 1R1, 1 + 2Rs are wing cells.

- **Trioxys bonnevillensis* (BS)

Microsiphoniella sp.

- **Lysaphidus adelocarinus* (BS)
- **Trioxys bonnevillensis* (BS)

Obtusicauda artemisiae (Cowen ex Gillette & Palmer)

- **Trioxys bonnevillensis* (BS)

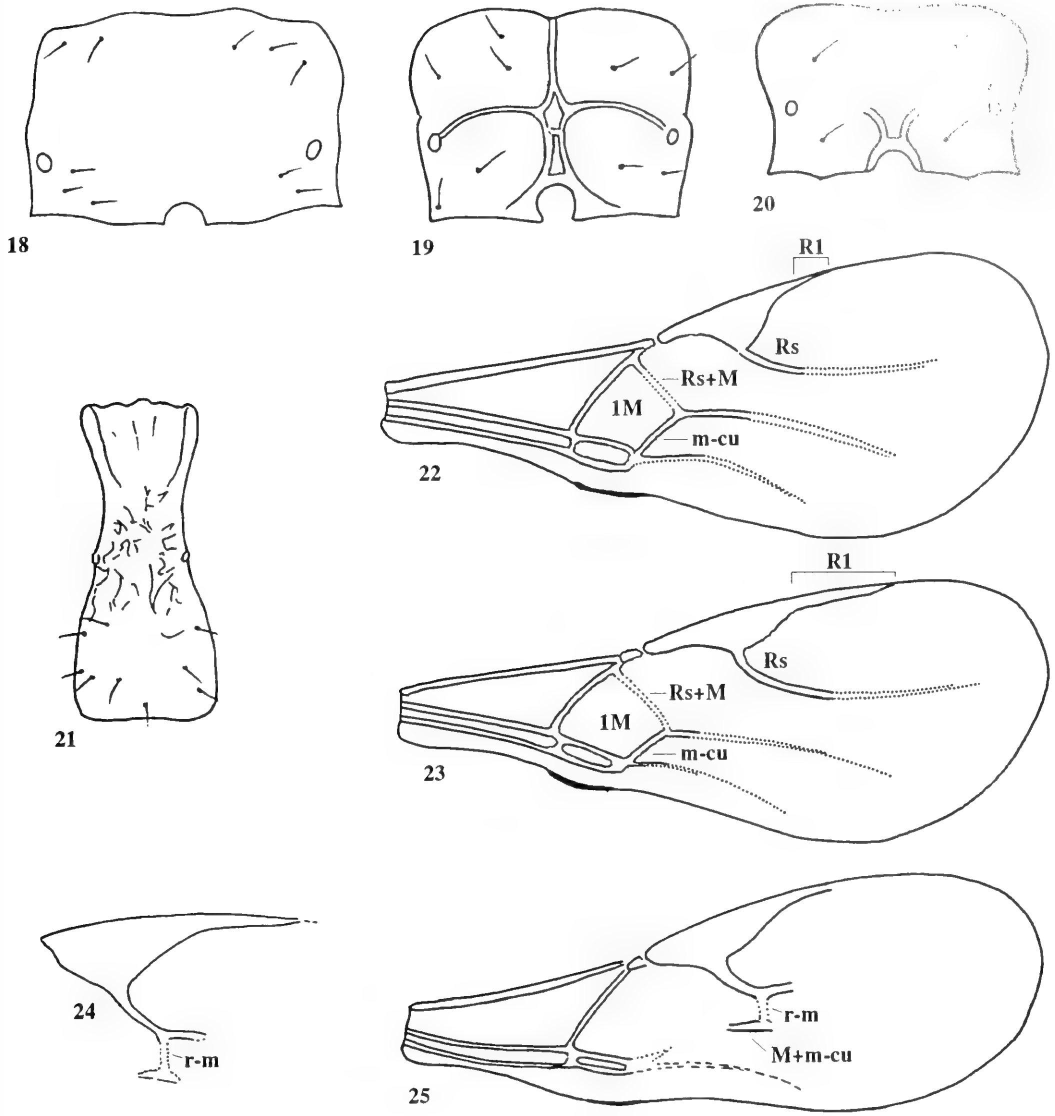
Obtusicauda artemisicola (Williams)

- **Binodoxys clydesmithi* (BS)
- **Lysiphlebus utahensis* (BS)
- **Lysaphidus adelocarinus* (BS)

Obtusicauda artemisiphila (Knowlton and Allen)

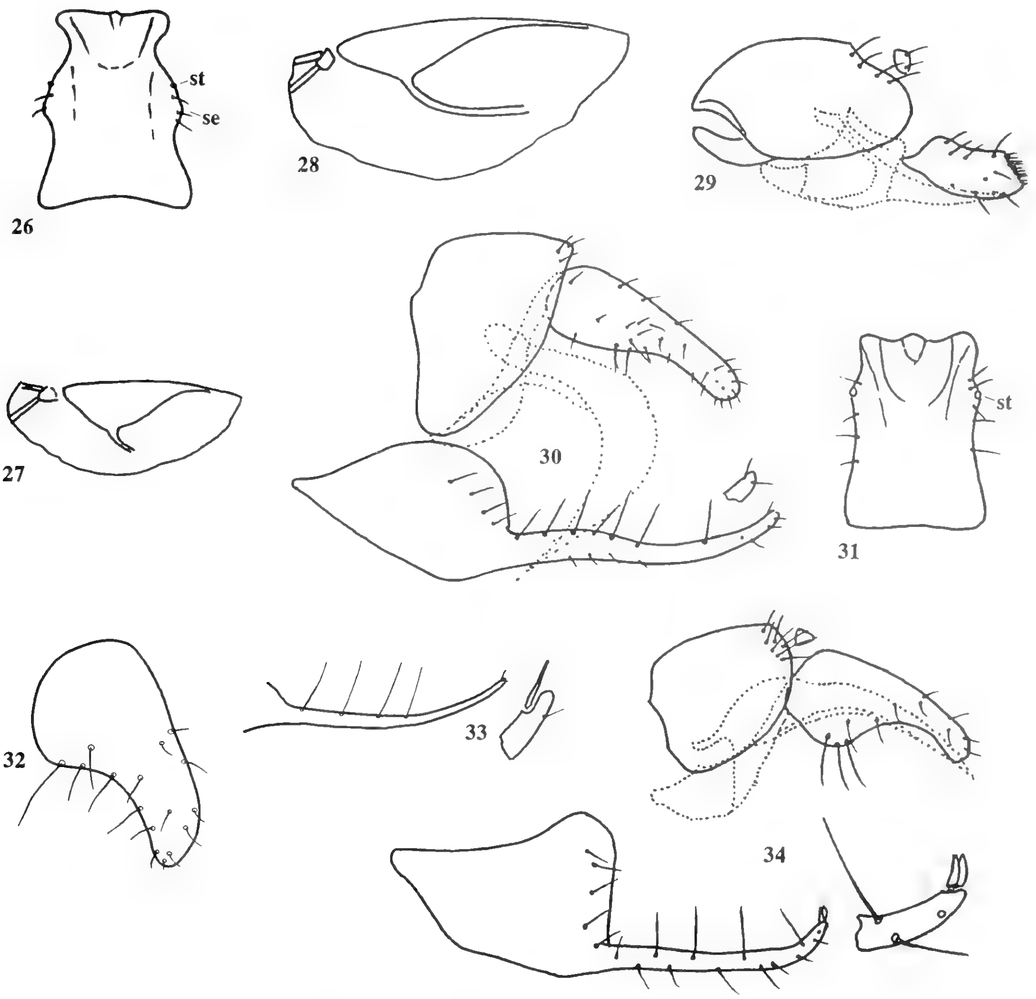
- **Ephedrus californicus* (PS)
- *Trioxys bonnevillensis* (BS)

Obtusicauda coweni Hunter



Figs. 18–25. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 18, 24, *Lysiphlebus utahensis*. 18, Propodeum. 24, Forewing, in part. 19, 21, *Lysaphidus ramithyrus*. 19, Propodeum. 21, Metasomal tergum 1. 20, 25, *Lysaphidus adelocarinus*. 20, Propodeum. 25, Forewing. 22, *Praon artemisaphis*, forewing. 23, *Praon occidentale*, forewing. Abbreviations: R1 (radial abscissa, = metacarpus), Rs (radial sector), Rs+M, M+m−cu, m-cu, and r−m are wing veins; 1M, wing cell.

  *_Binodoxys clydesmithi_ (BS)
  *_Binodoxys coruscanigrans_ (BS)
  *_Ephedrus californicus_ (BS)
  *_Lysiphlebus utahensis_ (BS)
  *_Praon artemisaphis_ (BS)
Obtusicauda filifoliae (Gillette & Palmer)
  *_Ephedrus californicus_ (PS)
  Lysaphidus adelocarinus (BS)
  *_Lysiphlebus utahensis_ (BS)
  Praon artemisicola (BS)
  Trioxys bonnevillensis (BS)
Obtusicauda sp.
  *_Ephedrus californicus_ (BS)
  Lysaphidus adelocarinus (BS)



Figs. 26–34. Various features of parasitoids of big sagebrush and prairie sage aphids (illustrations not to equal scale). 26, 28, 30, *Binodoxys clydesmithi*. 26, Metasomal tergum 1. 28, Forewing, in part. 30, Genitalia. 27, 31, 34, *Trioxys bonnevillensis*. 27, Forewing, in part. 31, Metasomal tergum 1. 34, Genitalia. 29, *Lysaphidus adelocarinus*, genitalia. 32, 33, *Binodoxys coruscanigrans*. 32, Ovipositor sheath. 33, Prong. Abbreviations: se, secondary tubercle; st, spiracular tubercle.

  **Praon artemisaphis* (BS)
  Trioxys bonnevillensis (BS)
Pleotrichophorus pseudoglandulosus (Palmer)
  Ephedrus californicus (PS)
Pleotrichophorus sp.
  **Lysaphidus adelocarinus* (BS)
  **Lysaphidus ramithyrus* (BS)
  Praon artemisaphis (BS)
  **Praon artemisicola* (BS)
  **Trioxys bonnevillensis* (BS)
Pseudoepameibaphis essigi Knowlton & Smith
  **Lysaphidus adelocarinus* (BS)
  **Trioxys bonnevillensis* (BS)
Pseudoepameibaphis glauca Gillette & Palmer
  **Lysaphidus adelocarinus* (BS)
Pseudoepameibaphis tridentatae (Wilson)
  **Lysaphidus adelocarinus* (BS)
  **Praon artemisicola* (BS)

  - **Trioxys bonnevillensis* (BS)
- *Zyxaphis canae* Williams
  - **Lysaphidus adelocarinus* (BS)
  - **Trioxys bonnevillensis* (BS)
- *Zyxaphis* sp.
  - **Binodoxys clydesmithi* (BS)
  - **Lysaphidus adelocarinus* (BS)
  - **Lysaphidus ramithyrus* (BS)

The aphid-parasitoid fauna on big sagebrush and prairie sage is indigenous and relatively diverse: in total 12 species of parasitoids were found associated with at least 15 species of aphids. A part of these parasitoid species are distributed over other western states and Mexico (Marsh 1979, Starý and Remaudière 1982, 1983, Starý 1983, Johnson 1987). Three of the parasitoid species (*Aphidius polygonaphis*, *Ephedrus californicus*, and *Praon occidentale*) are known to attack selected pestiferous aphids in adjoining crops or forest (Pike et al. 1996). The extent of their value, however, in terms of possible positive connections or movement between sage plant communities (endemic, typically undisturbed ecosystems) and neighboring agroecosystems or introduced landscapes is still largely undetermined.

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We express thanks to the Yakama Indian Nation for permission to collect and evaluate aphid and aphid parasitoids on their lands, and G. Remaudière (Muséum National d'Histoire Naturelle, Paris) for valuable help in aphid identification. This work was made possible in part by funds provided by Washington State University and the U.S. Department of Agriculture.

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A NEW SPECIES OF THE NEOTROPICAL GENUS *LISSOSCARTA* STÅL (HOMOPTERA: CICADELLIDAE: CICADELLINAE) THAT MIMICS WASPS

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*Abstract.—**Lissoscarta beckeri***, **new species**, a leafhopper that mimics wasps, is described from the states of Rondônia and Mato Grosso, Brazil. The new species can be distinguished from the other species of the genus by the following features: males with an elongate dorsoapical process in pygofer; aedeagus with a conspicuous dorsal lobe and without processes; paraphyses arched dorsally; abdominal sternum VII of females with a concavity on posterior margin. All members of the genus *Lissoscarta* have a strong constriction at the base of the abdomen, the forewings completely hyaline, and the form of the pronotum similar to the mesoscutum of a wasp. The size and color are similar to those of wasps of the tribe Polybiini (Vespidae: Polistinae). Morphological comparisons and field observations suggested that at least six species in four different genera of that tribe could be models for *L. beckeri*.

Key Words: Cicadellidae, *Lissoscarta*, new species, mimicry, wasps

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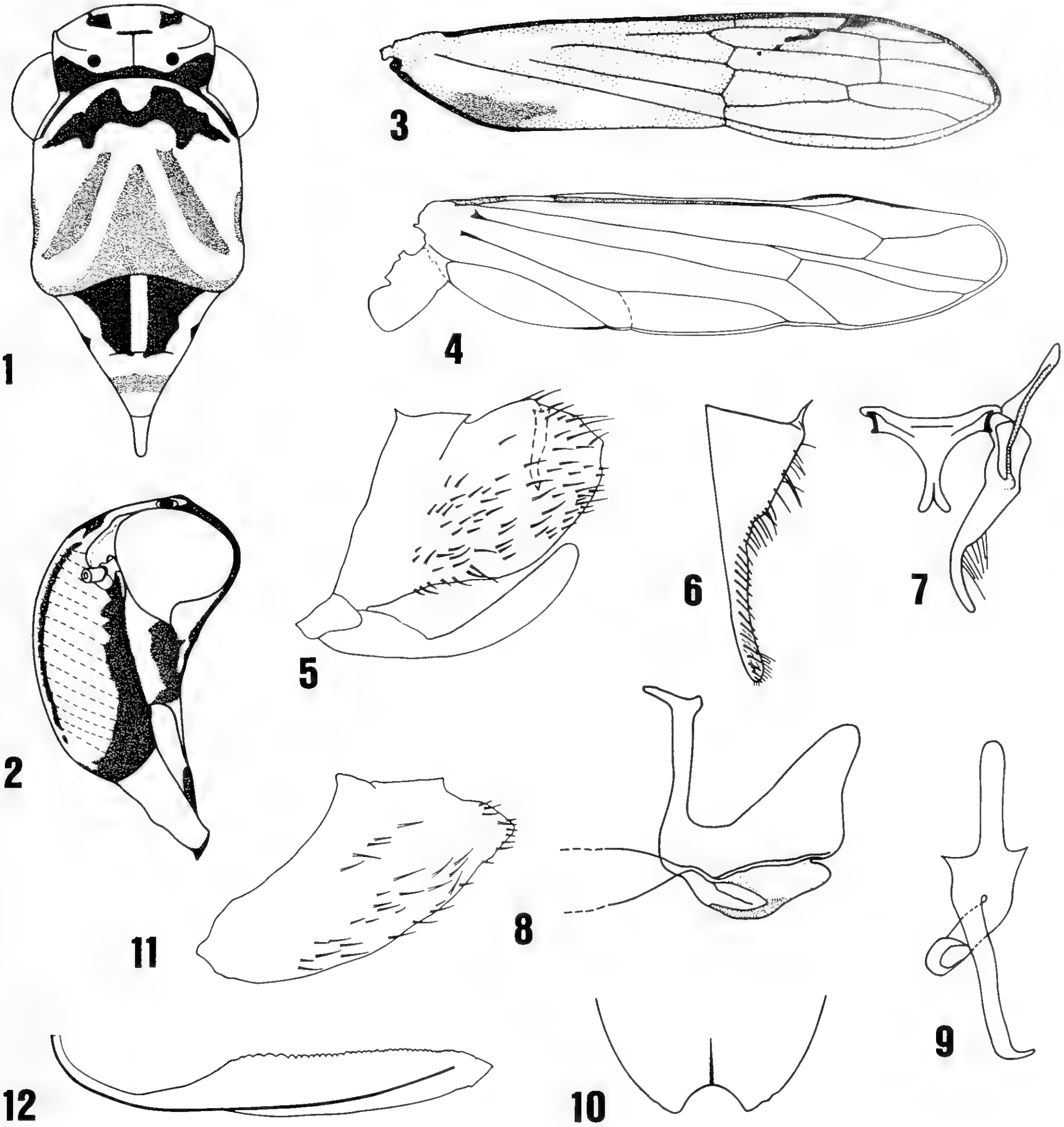
Six valid species of the Neotropical genus *Lissoscarta* Stål were recorded by Young (1977). The type species of the genus, *L. vespiformis* (Fabricius, 1803), has morphological and behavioral characters that enable it to mimic wasps (Evans 1947, Boulard 1978). The resemblance between *L. vespiformis* and wasps was first noted by Fabricius (1803) in the original description of the species (as *Cicada vespiformis*). The abdomen is strongly constricted at the base, the forewings are completely hyaline, and the form of the pronotum is similar to the mesoscutum of a wasp. When threatened, this leafhopper spreads its wings in a similar way to that of a wasp in the resting position, showing the constriction at the base of the abdomen. This behavior, in which the mimic suddenly exposes characteristics that resemble those of its model, is called "ostensible mimicry" (Boulard 1978). It is not found in any other known leafhopper genus. All the remaining species of *Lissoscarta* have the morphological features just mentioned (Young 1977), suggesting that "ostensible mimicry" is a characteristic of the genus. Unfortunately, no behavioral data are available for these other species.

In the present paper a new species of *Lissoscarta* from Brazil is described. Morphological comparisons, as well as field observations (J. Becker, personal communication), suggested that wasps of the tribe Polybiini (Vespidae, Polistinae) could be models for the new species. The characters supporting this view are discussed below.

Acronyms for collections in which the specimens used in this study are deposited are as follows: DZUP (Departamento de Zoologia da Universidade Federal do Paraná, Curitiba, Brazil), MNRJ (Museu Nacional do Rio de Janeiro, Rio de Janeiro, Brazil), and MZSP (Museu de Zoologia da



Figs. 1–12. *Lissoscarta beckeri*. 1, Head and thorax, dorsal view. 2, Head, lateral view. 3, Right forewing. 4, Right hindwing. 5–9, Male genitalia. 5, Pygofer and subgenital plate, lateral view. 6, Subgenital plate, ventral view. 7, Right style and connective, dorsal view. 8, Aedeagus, lateral view. 9, Paraphyses, dorsal view. 10–12, Female. 10, Abdominal sternum VII, ventral view. 11, Pygofer, lateral view. 12, Second valvula of ovipositor, lateral view.

Universidade de São Paulo, São Paulo, Brazil). In quotations of label data, a virgule (/) separates lines on a label and a semicolon separates information on different labels. Morphological terminology follows mainly Young (1977), excepting that of wing veins, which follows Dworakowska (1988). Nomenclature of wasp species follows Richards (1978) with modifications introduced by Carpenter and Day (1988).

Lissoscarta beckeri Mejdalani and Felix, new species

(Figs. 1–13)

Diagnosis.—*Lissoscarta beckeri* can be distinguished from the other species of the genus by the following features: males with dorsoapical margin of pygofer with elongate process extending ventrally; aedeagus with conspicuous dorsal lobe, without processes; rami of paraphyses arched dorsally; females with abdominal sternum VII with median concavity on posterior margin.

Description.—Length of male 14.8–16.0 mm; female 16.6–16.8 mm. Surface of pronotum convex in dorsal view, with sulcus near anterior margin. Forewing (Fig. 3) elongate, completely hyaline. Hindwing (Fig. 4) strongly narrowed, with slightly enlarged jugal lobe, vein AP' greatly reduced and AP'' + JA absent. Abdomen (Fig. 13) strongly constricted at base between segments III and IV. Remaining morphological characters of head and thorax as in the generic description of Young (1977: 148).

Color: Crown, pronotum and scutellum yellow. Crown (Fig. 1) with inconspicuous transverse brown line at apex of coronal suture, anterior margin with pair of black spots, posterior margin with sinuate transverse black stripe. Pronotum (Fig. 1) with sinuate transverse black stripe on anterior margin, median and posterior portions with elongate brown spot on each side of larger triangular brown spot, lateral margins with elongate brown spot. Mesonotum (Fig. 1) with pair of conspicuous black maculae extending from base to scutellar suture, basilateral margins with small black spot, scutellum with transverse dark brown stripe. Forewing (Fig. 3) with fumose area extending from near base of anal margin caudolaterally across clavus and becoming diffuse in corium. Hindwing with most of ScP + R + MA yellow. Face yellow. Clypeus (Fig. 2) with lateral and ventral margins black and with pair of longitudinal black stripes on muscle impressions extending to apical spots of crown. Clypellus (Fig. 2) with blackish apex. Lora (Fig. 2) with black spot on inferior portion. Genae (Fig. 2) with black spot below eyes, dorsoposterior margin black. Thoracic sterna yellow. Anterior tibiae brown, with black stripe along ventral margin. Abdomen (Fig. 13) with tergites yellowish-brown, posterior margins with transverse yellow stripe.

Male genitalia (Figs. 5–9): Pygofer (Fig. 5) moderately produced in lateral view, with posterior margin convex; with macrosetae numerous, lacking only on basidorsal area; dorsoapical margin with elongate process extending ventrally. Subgenital plates (Figs. 5, 6) in ventral view elongate, triangular, extending posteriorly almost as far as pygofer apex; with uniseriate macrosetae; microsetae also present. Style (Fig. 7) extending posteriorly considerably beyond apex of connective, without preapical lobe; preapical area with group of setae; apex rounded. Connective (Fig. 7) T-shaped. Aedeagus (Fig. 8) symmetrical, with conspicuous dorsal lobe in lateral view; ventral margin with longitudinal sulcus. Paraphyses (Fig. 9) with pair of asymmetrical rami directed dorsally.

Female genitalia (Figs. 10–12): Abdominal sternum VII (Fig. 10) broad in ventral view, with median concavity on posterior margin. Pygofer (Fig. 11) well produced in lateral view, triangular, with apex narrowly rounded; most macrosetae on apex and extending anteriorly along ventral margin, small number below dorsal margin. Second valvulae of ovipositor (Fig. 12) expanded beyond basal curvature, preapical prominence discrete, apex acute; shaft bearing teeth throughout expanded portion, except on apical area, teeth quadrate, sloping and bearing minute secondaries, apex with numerous denticles on dorsal and ventral margins.

Type material.—Holotype: ♂, Brazil, "Ouro Preto/ d'Oeste-RO/ 21-X-1986/ J. Becker col.", MNRJ. Paratypes: One ♂, one ♀, same data as holotype, MNRJ. One ♂, "Pimenta Bueno-RO/ 23-X-1986/ J. Becker col.", MNRJ. One ♂, one ♀, "Vila Vera MT/ Brasil X-1973/ M. Alvarenga Leg", DZUP.

Additional material.—Dr. M. W. Nielson (Brigham Young University, Utah, U.S.A.) identified, using a manuscript of our paper, eight specimens of *L. beckeri* in the collection of the Utah State University. He has kindly sent us the information on the labels of these specimens: "One ♂, one ♀, Brazil: Rondonia, 62 mi. SE Ariquemes, 15–22 March 1991, W. Hanson, G. Bohart; two ♂, one ♀, same data as above except 13–25 April 1992, W. J. Hanson; one ♂, two ♀, same data as above except 17–24 May 1989, 180 m, W. J. Hanson."

Notes.—This species keys to *Lissoscarta vespiformis* in Young's (1977) key. The convex posterior margin of the pygofer (Fig. 5) and the conspicuous dorsal aedeagal lobe (Fig. 8) of *L. beckeri* are similar to those of *L. vespiformis*, but the latter does not have pygofer processes and the rami of its paraphyses are more symmetrical; the posterior margin of female abdominal sternum VII (Fig. 10) is distinctly concave in *L. beckeri* and only slightly emarginate in *L. vespiformis*. The unpaired dorsal aedeagal processes of *L. schlingeri* Young, *L. pereneensis* Young, *L. catutara* Young, and *L. nipata* Young will readily distinguish them from *L. beckeri*; in *L. catutara* the posterior margin of female sternum VII is also only slightly emarginate. *Lissoscarta pebasensis* Young is known only from the holotype female (Young 1977); the abdominal sternum VII of this species has a regularly convex posterior margin that distinguishes it from *L. beckeri*. The new species is named in honor of Prof. Johann Becker (Museu Nacional, Rio de Janeiro), who has collected many interesting Homoptera in Brazil.

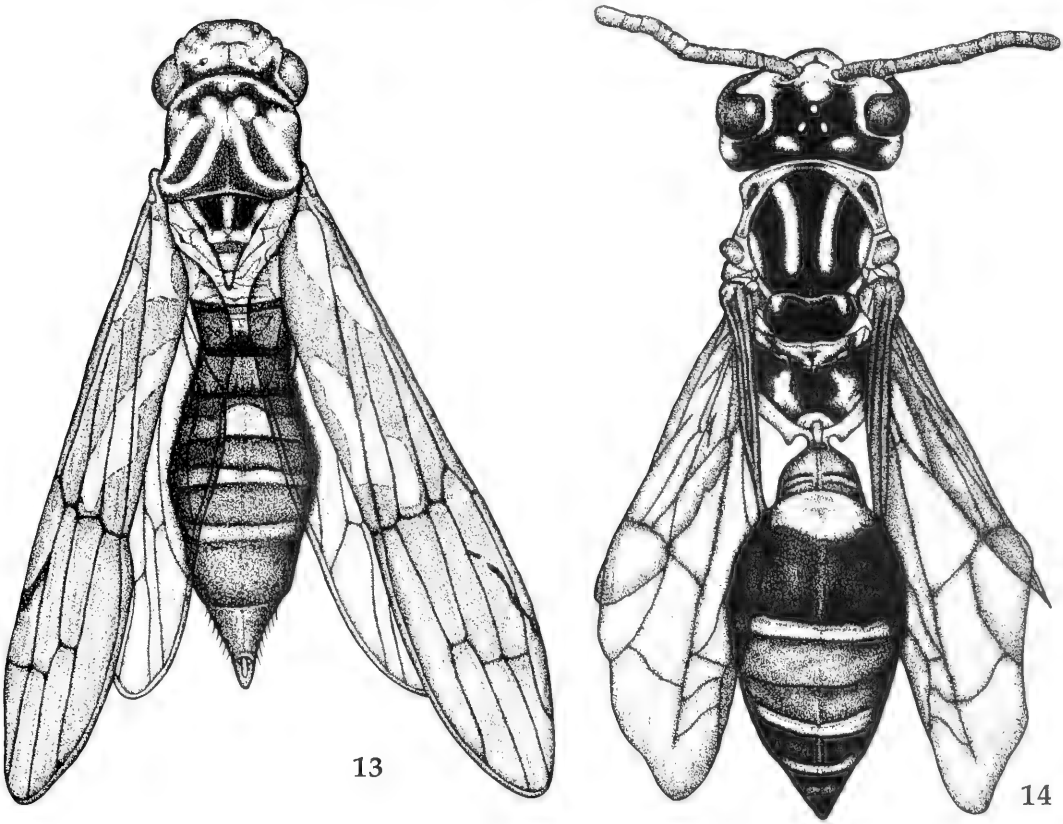
DISCUSSION

We have studied wasp species belonging to four genera of the tribe Polybiini: *Agelaia* Lepeletier [*A. fulvofasciata* (Degeer), *A. flavipennis* (Ducke), and *A. hamiltoni* (Richards)], *Pseudopolybia* Saussure [*P. difficilis* (Ducke)], *Polybia* Lepeletier [*P.* (*Pedothoeca*) *emaciata* Lucas], and *Mischocyttarus* Saussure [*M.* (*Haplometrobius*) *undulatus* (Ducke)]. The specimens examined are deposited either in MNRJ or MZSP and were determined by O. W. Richards, excepting a single specimen of *A. fulvofasciata* from the type locality of *L. beckeri*, which was identified by the authors. These species are very similar in terms of color pattern, a fact indicating that they are part of a group of Müllerian mimics. The head and thorax in all of them are yellow, being similarly marked by dark spots and stripes. The abdominal tergites are yellowish-brown and often present a yellow transverse stripe at posterior margin.

The features mentioned above, which are here exemplified by *A. fulvofasciata* (Fig. 14), are mimicked by *L. beckeri* (Fig. 13). This represents a case of Batesian mimicry. The presence of dark spots and stripes on the head and thorax of the leafhopper, as well as the transverse yellow stripes at the posterior margin of the abdominal tergites, are remarkable characters. All wasps studied occur within the geographical range of *L. beckeri* (see Richards 1978). They are approximately the same size as the mimic.

In terms of morphology, the constriction at the base of the abdomen of *L. beckeri* is an important character (Fig. 13). This constriction mimics the constricted zone (petiole) at the base of the abdomen of the wasps. The fore- (Fig. 3) and hindwings (Fig. 4) of *L. beckeri* are hyaline, resembling those of the polybiines mentioned. The hindwings are also strongly narrowed, having a form very different from that usually found in other members of the subfamily Cicadellinae. The vein AP′ is greatly reduced and AP″ + JA is absent. The convex pronotum of *L. beckeri* mimics the mesoscutum of the wasps.

Agelaia fulvofasciata (Degeer) is a model for *L. beckeri* in the type locality of the latter. It is apparently more common than the leafhopper (J. Becker, personal communication). Becker also observed that *L. beckeri* can rest upon the leaves with its wings spread in wasp-like manner. This behavior is similar to the "bluffing display" described by Boulard (1978) for *L. vespiformis*. In agreement with its wide range, commonness and aggressive behavior, *A.*



Figs. 13–14. 13, *Lissoscarta beckeri*, dorsal habitus of female. 14, *Agelaia fulvofasciata*, a model of *Lissoscarta beckeri*, dorsal habitus of female.

fulvofasciata is mimicked by many species of wasps and other insects (Richards 1978). Indeed, Richards and Richards (1951) observed that it is also a model for *L. vespiformis*.

Using Vane-Wright's (1976) terminology and analytic schemes, this case of mimicry would be Class VI (antergic defensive). This class includes Bates' original formulation of mimicry (Vane-Wright 1976). The predators (operators) from which such mimicry affords protection are unknown. Therefore, it is not possible to establish whether this mimicry is disjunct (mimic, model, and operator are different species) or bipolar (model and operator are the same). More field observations are necessary to settle this question. At least two other cases of antergic defensive mimicry have been reported in Homoptera. Hogue (1984) speculated that lanternflies (*Fulgora* spp.) avoid predation by mimicking arboreal lizards. Zolnerowich (1992) described a nymph of *Amycle* sp. (Fulgoridae) that mimics jumping spiders (Salticidae). In these two cases the model and operator were considered the same (bipolar).

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We are grateful to J. Becker (MNRJ) for making available for study specimens under his care and for providing invaluable information about mimicry in *L. beckeri*. We also thank the following persons for lending specimens of *Lissoscarta*: R. R. Cavichioli (DZUP), M. D. Webb (The Natural History Museum, London), and U. R. Martins (MZSP). C. R. Brandão (MZSP) helped a

great deal with the identification of *A. fulvofasciata* and made available for study wasps under his care. The habitus drawings of *L. beckeri* and *A. fulvofasciata* were inked by M. F. Pessôa. The manuscript benefited from the comments of J. Becker, F. A. Bockmann, A. L. Carvalho, C. H. Dietrich, L. F. Dorvillé, W. J. Knight, J. L. Nessimian, M. W. Nielson, E. R. da-Silva, M. D. Webb, and two anonymous reviewers.

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BIONOMICS OF *LASIOGLOSSUM* (*EVYLAEUS*) *MATIANENSE* (BLÜTHGEN) (HYMENOPTERA: HALICTIDAE), THE PREDOMINANT POLLINATING BEE IN ORCHARDS AT HIGH ALTITUDE IN THE GREAT HIMALAYA OF GARHWAL, U.P., INDIA

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Abstract.—The halictine bee, *Lasioglossum* (*Evylaeus*) *matianense* (Blüthgen) is the most abundant bee in early May, pollinating apples soon after snowmelt at Harsil, India (elevation 2600 m), and pollinating *Prunus* sp. at Gangotri, India (elevation 3100 m). It nests in south-facing, sunny banks, where density reaches 2403 nests per m^2 ($\bar{x}$:290 nests per m^2). The nests of this probably solitary species are short, sinuous, nearly horizontal burrows, ending in 1 or 2 cells at a mean depth of 6.2 cm. This bee thermoregulates its nests by placing them in relatively cool, moist soil among grass roots near the tops of the banks.

Key Words: Himalaya, pollination, apple, *Prunus*, bee, nests, thermoregulation

Worldwide, there are about 2,000 species of halictine bees, popularly called 'sweat bees' because some lick salty sweat. They are important pollinators of crops and wild plants in all terrestrial habitats, including Arctic tundra, the world's highest mountains, wettest rainforests, driest deserts, vast prairies, temperate forests, and urban gardens. Because most species are small, dark, and inconspicuous, and nest underground, people often overlook them, even when they are very abundant in habitats. They are also difficult to identify taxonomically. Halictine bees, including *Evylaeus*, are of great interest for the study of sociobiology and evolution, because they have such a diversity of social behavior, ranging from strictly solitary species to communal, semisocial, and eusocial (*sensu* Batra 1966) bees that share nests (see Packer and Knerer 1985 for a review). Some species may be eusocial in a favorable habitat with a long growing season, but live a solitary life where the growing season is too short to permit the development of social colonies, for example, *L.* (*Evylaeus*) *calceatum* (Scopoli) (Sakagami and Munakata 1972).

The subgenus *Evylaeus* of *Lasioglossum* is most abundant and diverse in cold climates of North America and Eurasia. Two species, *L.* (*E.*) *rufitarse* (Zetterstedt) and *L.* (*E.*) *borealis* Svensson, Ebmer, Sakagami, are Holarctic (Sakagami and Toda 1986). *Evylaeus* is divided into two groups, those in which the females have a carina on the posterior edge of the propodeum (Svensson et al. 1977), and those without a carina. Carinate species often construct their nests so that the subterranean brood cells are arranged to form delicate earthen combs that are surrounded by airfilled cavities (Batra 1990). In general, nests of carinaless species lack combs (based on a sample of fewer than 20 species). According to A. W. Ebmer (in litt.), *L.* (*Evylaeus*) *matianense* (Blüthgen, 1926) belongs to the holarctic *L.*

(*E.*) *nitidiusculum* taxonomic species-group.

From March 5 to May 8, 1995, I undertook a survey of bees that pollinate rosaceous fruit crops in the Garhwal Himalaya, U.P., India (Batra in press). The Shivalik range and Lesser Himalaya were surveyed at several locations (77°30′ to 79°00′E; 30°15′ to 30°30′N), at altitudes from 579 to 3100 m above M.S.L. during March and April. Beginning on May 1, I studied the pollinators of apples growing at and near Harsil (elevation 2600 m; 78°45′E, 31°02′N) and *Prunus* sp. at Gangotri (elevation 3100 m; 78°57′E, 31°00′N). This area is in the subalpine zone of the Great Himalaya Range (Mani 1962; Mani 1978), about 20 km south of the Tibet (China) border, in a deep valley on the upper Bhagirathi Ganga River, surrounded by snow-capped peaks of over 6000 m elevation. Apples are grown on terraced slopes to 3100 m elevation. Timberline is at about 3600 m. Mornings were clear, but strong southerly orographic updrafts brought haze, clouds and chilly precipitation after noon, and cold, katabatic drafts blew down from the glaciers to the north at night. The pollinating bees on early-bloom apples and full-bloom pears at first included no honey bees. Almost all of the bees were halictines, especially *L.* (*E.*) *matianense*. Various Diptera were abundant on the apple flowers. No *Apis cerana* F. live at, or north of, the apple-growing district of Sukhi (elevation 2487 m) where, according to local growers, beekeeping is not practiced. *Apis laboriosa* Sm. foragers suddenly appeared on apple blossoms at Harsil on May 5. They were some 600 km west of the previously known range of this seasonally migrating giant honey bee in Nepal (for behavioral details, see Batra 1996).

Although some 9000 species of seed plants grow in the 1450 km^2 area of the western Himalaya that is above 1200 m elevation (Polunin and Stainton 1984), and some 4000 species are endemic to the Himalaya (Mani 1978), very little is known about their pollinators, most of which may be endemic, as are other Himalayan insects (Mani 1962). Due to its remoteness and difficulty of access, the bees of the Great Himalaya Range are practically unknown. No work on the pollination of the temperate crops that are grown in these enormous, extensive, and rugged mountains has been conducted. This is significant, because this region is adjacent to the centers of origin for several important crops, thus, efficient coevolved pollinators of these crops should occur there. Previous work on crop pollination in the Himalaya has been conducted in the Lesser Himalaya, which are influenced by the monsoon and have a more moderate climate (Batra in press).

The Harsil area is of particular ecological interest because it lies just north of the crestline of the Great Himalaya Range. Harsil and Gangotri are in the rain shadow of Srikanta (6132 m elevation), Jaonli (6632 m) and Phating Pithwara (6904 m), which partially block the southeast monsoon. *Artemisia* and other xerophytes that are characteristic of Middle Asia (Mani 1978) grow there. The river valley and its orchards are surrounded by extensive glaciated areas. Apple orchards were first planted beside the river at Harsil about 75 years ago, and some of the original trees are still living there, according to local growers. Apples and other fruit trees were subsequently planted extensively on terraces where the native *deodar* cedars were cleared, from Sukhi to the south (2500 m elevation) and at several locations along the river, to the east and upstream of Harsil, as far as Gangotri (elevation 3100 m). These may be among the world's higher orchards (Fig. 2). Apple varieties include c.v. 'Delicious', c.v. 'Bijou' and a wild-type, seedy, 'Kashmiri' apple. Other fruits grown at sheltered sites along the river in the area include pear, plum, quince, *chulu* apricot, and almonds.

POLLINATION

I collected apple pollinators on May 1 and from May 5 to 7 at Harsil, by sweeping

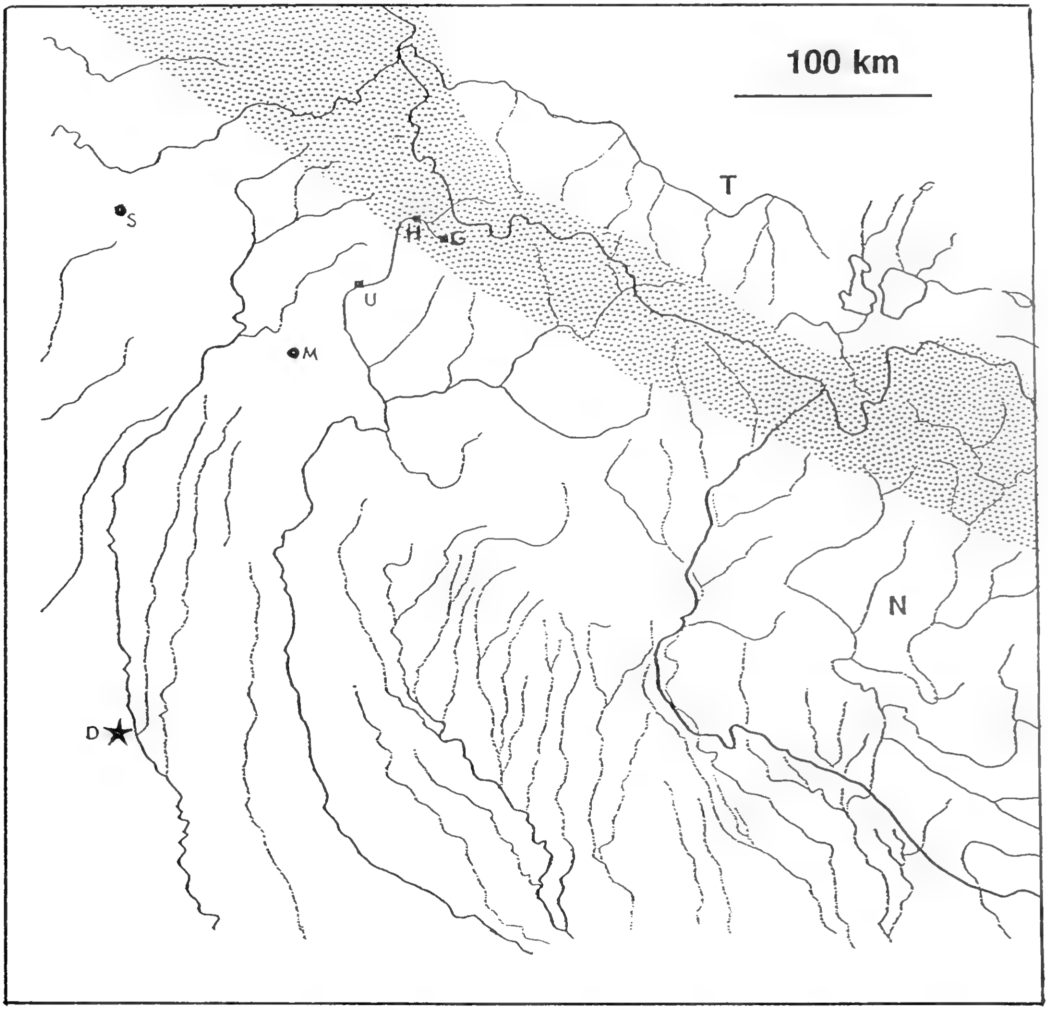

Fig. 1. Location where *L.* (*E.*) *matianense* was collected in Garhwal: H, Harsil; G, Gangotri. The stippled area represents the Great Himalaya Range (Himadri), where many peaks are over 6,000 m and valleys are over 2000 m. Other locations are: T, Tibet; N, Nepal; U, Uttarkashi; D, Delhi. Shimla (S) and Mussoorie (M) are 'hill stations' on the crests of ridges at 2206 m and 2006 m respectively, in the Lesser Himalaya (Himanchal). Between Himanchal and Himadri are subtropical valleys, as low as 500 m in elevation.

the canopy with a long-handled insect net. Although sunrise occurred at 6:30 local time, due to the chilly nights, bees did not begin to fly until 9:00, and maximum foraging activity was between 10:00 and 13:00. In the early afternoon, strong southerly winds and cloudiness developed daily. The bees were very sensitive to any dimming of the brilliant sunshine, and they left the orchard before rain, hail, and snow fell.

The most abundant pollinating bee on apple bloom at Harsil was *L.* (*E.*) *matianense*. On May 1, 93% (98 of 106) of the bees that were collected were this species. At another site near Harsil on May 6, 75% (49 of 65 bees) on apples were *L.* (*E.*) *matianense*. I also collected pollinators on *Prunus* sp. (? *P. mira*) growing near melting snowbanks on May 3 and 4 at Gangotri (apples were not yet in bloom there). At this location, also, *L. matianense* was the predominant bee. For comparison, at

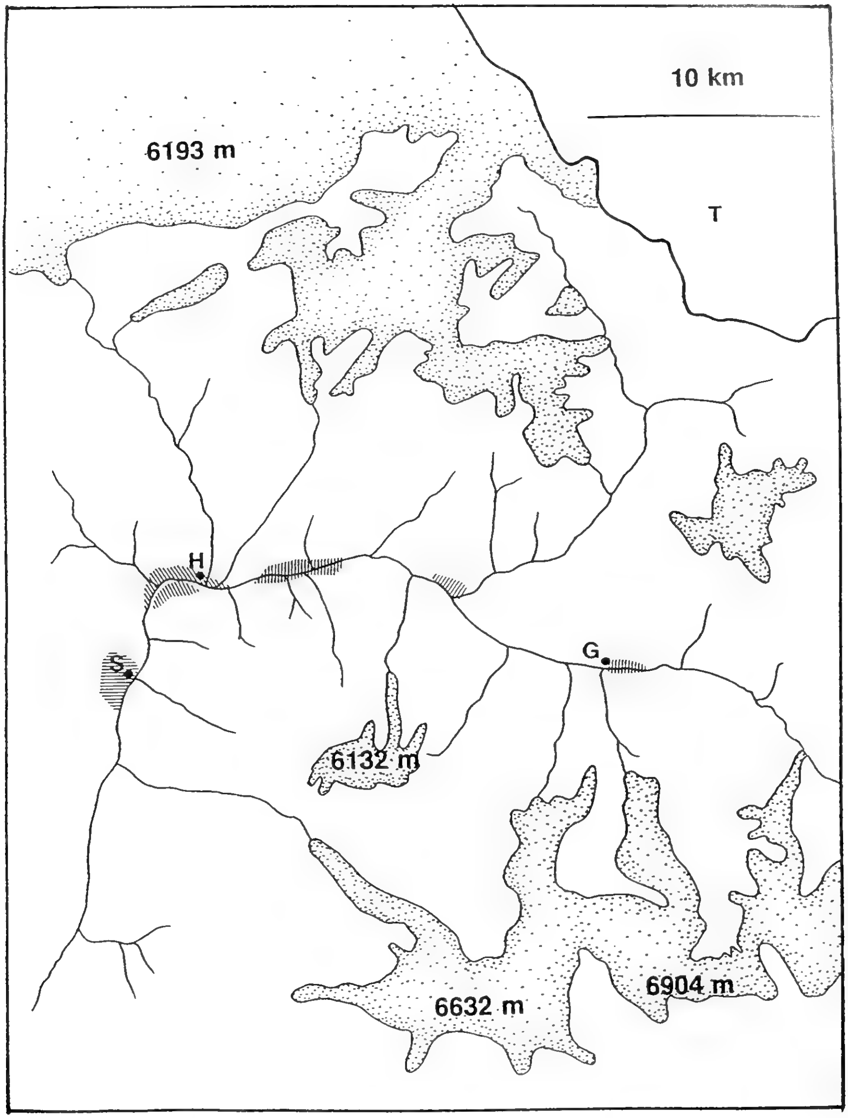

Fig. 2. Map of the Harsil area, showing surrounding high peaks (numbers indicate elevation in meters), glaciated areas (stippled), and locations of the orchards (hatched areas). S = Sukhi; H = Harsil; G = Gangotri; T = Tibet.

Dhanaulti (2200 m elevation) in the Lesser Himalaya, *Apis cerana* were by far the most abundant pollinators of apples in mid-April; beekeeping being widely practiced there. Halictine bees, especially both sexes of *L.* (*E.*) *marginatum* Brullé, were second in abundance (at about 10% of the total). The predominance of halictines at high elevations, and the scarcity of *Andrena*, *Osmia*, and *Bombus*, both in numbers of individuals and in diversity of species, were unexpected findings. These three genera (especially *Andrena* spp.) are the most important native, unmanaged apple pollinators in North America and Europe (Boyle and Philogène 1983; Boyle-

Makowski 1987; Scott-Dupree and Winston 1987, and references therein).

AGGREGATION AND THERMOREGULATION

A large aggregation of the nests of *L.* (*E.*) *matianense* was discovered on May 7, in a steep, sunny, south-facing slope, about 100 m above the orchard near Wilson Cottage at Harsil. Foraging females were returning with large loads of apple pollen. This slope was an overgrazed pasture, where most of the original *deodar* cedars had been removed. Scattered large trees provided patches of shade. Several trails had been cut into the slope by grazing yaks, mules, and goats, and the bees' nests were in the ca. 0.5 to 1.0 m-high bank of soil that had been exposed on the upslope sides of these livestock trails. The underlying soil was glacial till, a mixture of fine, micaceous silt and sand, mixed with pebbles, cobbles, and flat, gleaming, micaceous rocks. Above it was 20–30 cm layer of moist loam, filled with the rootlets of short grasses and forbs, such as *Taraxacum* and *Fragaria*, that were just beginning their spring growth. This area was probably glaciated within the past 10,000 years. The Bhagirathi Ganga River emerges from a retreating glacier near Gangotri at about 4000 m elevation. Next to the zigzag livestock trails, *L.* (*E.*) *matianense* nests formed patches of dense aggregations where the south-southeast aspect and insolation appeared to be favorable. Counts of all nest entrances in 31 meter-square sections were made at 5 locations within a 100 m^2 area, along 4 of the trails. Total nests per m^2 included samples with mostly soil, and samples that contained large, obstructing rocks and roots, which were less favorable for nesting. Results are as follows:

Site 1 (7 m^2 samples): 20 (rocky) to 348 nests per m^2; $\bar{x} = 165$ nests per m^2.
Site 2 (6 m^2 samples): 10 (roots) to 545 nests per m^2; $\bar{x} = 115$ nests per m^2.
Site 3 (12 m^2 samples): 50 to 2403 nests per m^2; $\bar{x} = 376$ nests per m^2.
Site 4 (5 m^2 samples): 15 (rocky) to 369 nests per m^2; $\bar{x} = 182$ nests per m^2.
Site 5 (1 m^2 sample): 130 nests.

The mean for all 5 sites was 290 nests per m^2; 7303 nest entrances were counted within the 31 m^2 total area surveyed. Because similarly suitable habitat extended for an estimated 300 m along the livestock trails on the slope above the orchard, as many as 87,000 nests of *L.* (*E.*) *matianense* may have been present.

The Himalaya are notable for extreme variability of microclimates, the result of their high elevation, rugged terrain, continentality, and relatively low latitude. A combination of diurnal insolation and nocturnal radiation, atmospheric aridity, cold, low oxygen pressure, rapid desiccation, strong winds, and extreme daily temperature fluctuations affects all life. Small, microclimatic differences in aspect, light and shade may change the length of the growing season and time of crop maturity at a location by up to 3 weeks (Whiteman 1985). At the elevation of Harsil, the frost-free growing season is about 24 weeks (Mani 1978). In the Great Himalaya, the atmospheric mean temperature increases rapidly from March to June, but then it stabilizes by July, due to monsoon cloud cover, before declining after August (Mani 1978). *Lasioglossum* (*E.*) *matianense* has exploited the brief period of intense insolation and warmth that exists in May and June, when it makes and provisions its nests and its brood develops. It has also exploited the phenomenon that south-facing slopes receive twice as much solar radiation as north-facing slopes (Whiteman 1985), by nesting in south-facing slopes. In North America, the vernal bee *L. (Evylaeus) comagenensis* (Knerer and Atwood) similarly nests where it maximizes insolation (Batra 1990a), as do *Andrena alleghaniensis* Viereck (Batra 1990b) and *A. fenningeri* Viereck (Batra, in litt.). In Japan, *L.* (*Evylaeus) duplex* (Dalla Torre) selects nest sites that receive direct morning sunshine (Sakagami and Hayashida 1961).

The nests of *L.* (*E.*) *matianense* were not randomly distributed in the banks next to the livestock trails. The great majority of nests were in the topmost layer of soil at all of the 31 sites examined. Nests were made in a 10–15 cm thick zone of dark, loamy, moist soil, among the tough, fibrous rootlets of the short turf grasses and forbs. The entrances to many nests were hidden, and partly shaded by an overhanging thatch of grass blades and dangling rootlets (Fig. 3). At site 3, where nests were the densest (2403 per m^2), nest entrances were as close as 2 mm. This made orientation difficult for returning foragers, which hovered, zigzagging in front of the bank, before finding their nests. About 150 flying, humming, bees per m^2 were visible at a glance. This is one of the higher nest densities among bees. Another solitary species, *L.* (*Evylaeus)* sp. nr. *fulvicorne* (Kirby) nests in aggregations that reach 101 nests per m^2 ($\bar{x}$ = 54 per m^2; Maeta 1966).

In order to study the reason for the limited dispersal of the nests of *L.* (*E.*) *matianense*, two calibrated, bimetallic, dial probe thermometers were inserted at 2 locations into the soil at site 3 and kept there all day. One thermometer was inserted to depths of 5, then 15 cm, into the moist, loamy rootlet zone where the maximum nests had been made. The other thermometer was inserted near the first, at 5, then 15 cm, in a drier, sandy area about 30 cm below the first, where there were no nests. Temperatures were recorded periodically at 5 and 15 cm in the nest zone and at the same times in the nestless zone. The moist, loamy soil that was selected by the bees for nesting maintained a more constant and lower daily temperature than the sandy soil that was avoided by the bees (Fig. 4). Evidently, the insulating thatch of grass and the moisture retained by the rootlets buffered the nests and brood cells (mean depth, 6.2 cm) from daily temperature extremes and desiccation.

NEST ARCHITECTURE

Fourteen complete, open nests with brood cells and 23 miscellaneous cells of *L.* (*E.*) *matianense* were excavated (Fig. 3). The circular nest entrances were 2.5 to 3.0 mm in diameter, and were somewhat irregular, without any noticeable modifications made by their inhabitants. The main tunnels were sinuous, 4.0–4.5 mm in diameter, and 2.5 to 11.0 ($\bar{x}$ = 6.2) cm deep, ending in a cell. Eleven nests terminated at one cell, and 3 nests had 2 cells each. The nest tunnels were intertwined among each other and among rootlets and stones. The friable, fine, loose soil and rootlets made it difficult to trace individual tunnels.

The contents of undamaged brood cells varied. Five cells were new, open, and unprovisioned, smelling of the characteristically tangy Dufour's gland secretion, which is used by the bees to waterproof the interior of cells. Marks made by pygidial plates could be seen in their shiny, smooth interiors. The slightly milky, transparent secreted cell linings penetrated the surrounding soil, which contained flat mica particles that formed a terrazzo-like pattern in cells. The cells were of the usual halictine shape (Fig. 3). Five cells were open, containing small, incomplete balls of moist, medium-yellow apple pollen, with a dusting of loose, dry pollen. Ten cells were sealed with a plug of loose soil. Each of these contained a moist, medium-yellow flattened spheroid of pollen with a groove on top containing an arched, white 2.0 mm-long egg. These pollen balls were 3.5–4.0 mm in diameter and 2.0–2.5 mm high. They contained 95% apple pollen (n = 5). Brood cells were 7.5–9.0 mm long, and 4.0–4.5 mm in maximum width, with a 2.0–2.5 mm neck. No cells contained larvae, pupae, or adults. The distal ends of about 80% of cells extended into the bank, but the ends of some cells were directed toward the front of the bank, when burrowing bees had encountered rocks. Some cells were built

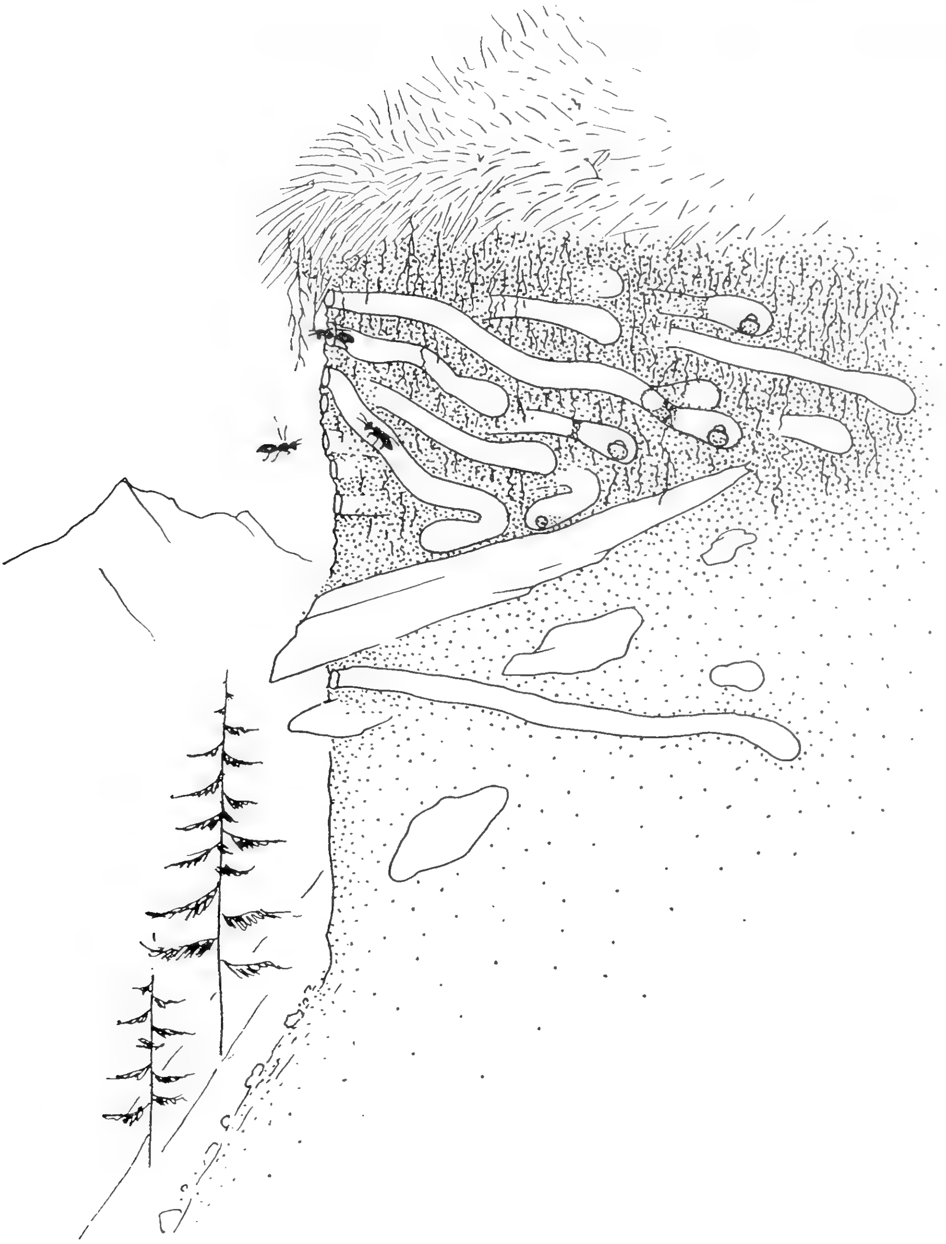

Fig. 3. Nests of *L.* (*E.*) *matianense* among the fibrous rootlets of grasses in the loamy, moist, upper 10–15 cm of a sunlit bank next to a livestock trail.

against rocks, separated from them by 1 mm of soil.

There was no evidence of social behavior, which is unlikely to develop, due to the brief growing season. One nest contained a female cleptoparasitic halictine, *Sphecodes* sp.; others were empty or contained a single *L.* (*E.*) *matianense* female. No male *L.* (*E.*) *matianense* was collected at the nest site or in the orchards. There were few traces of

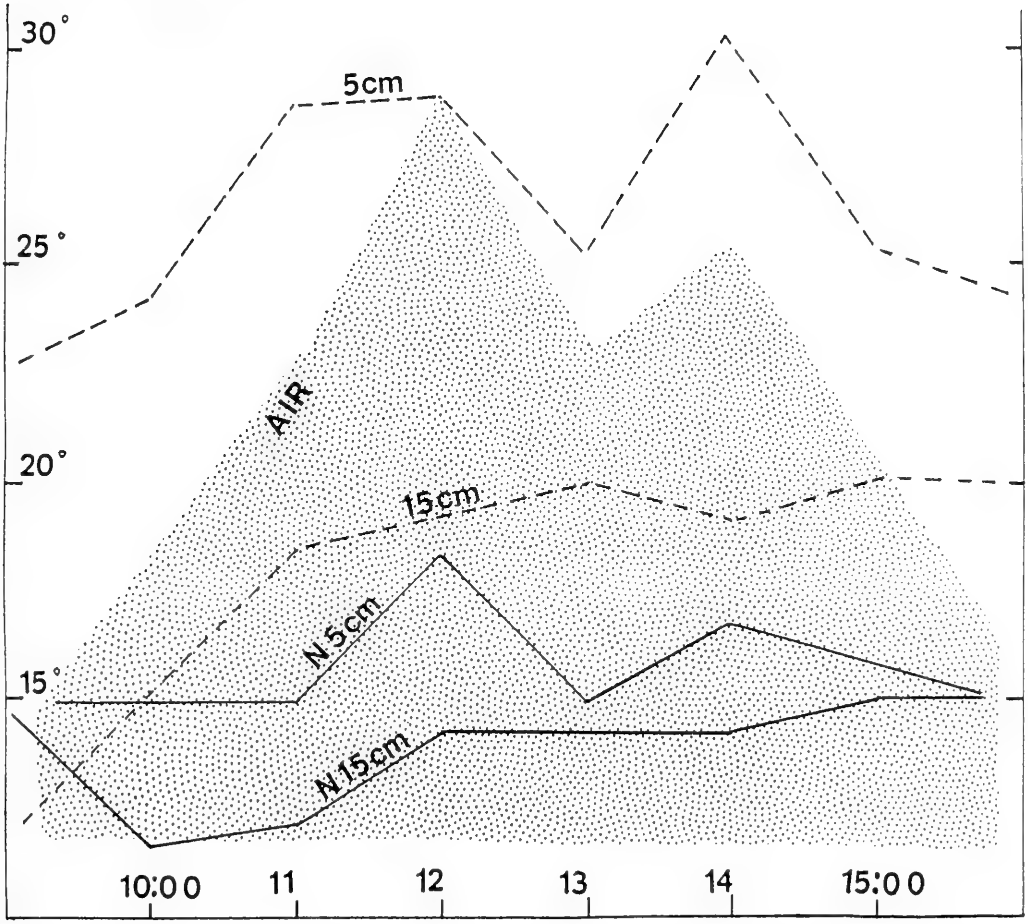

Fig. 4. Thermoregulation may be accomplished by the placement of nests. The moist, loamy soil in the upper 20 cm of the bank among the rootlets where *L.* (*E.*) *matianense* nests (N) stays cooler, and temperatures there, at 5 cm and 15 cm, fluctuate less, than in the lower, drier, and sandier portion where the bees did not nest (dashed lines). Diurnal air (stippled area) and soil (lines) temperatures were recorded on May 7.

abandoned cells from previous years' nesting. Frass from one such cell contained apple pollen exine.

CONCLUSION

The simple, combless nests of *L.* (*E.*) *matianense* resemble the nests of the Holarctic, solitary, boreal species *L.* (*E.*) *borealis* (Svensson et al. 1977; Sakagami and Toda 1986). Other similarly combless, solitary, boreal species are *L.* (*E.*) *sakagamii* which ranges from northern Japan to Manchuria (Sakagami et al. 1982), and *L.* (*E.*) *allodalum* Ebmer et Sakagami, from northern Japan (Sakagami et al. 1985). The other solitary, Palearctic species of *Evylaeus* make earthen combs of cells; for example, *L.* (*E.*) *nupricola* Sakagami, a boreo-alpine, ice-age relic in northern Japan (Sakagami 1988), and *L.* (*E.*) *calceatum*, which is solitary at high, cold elevations, but is eusocial in more temperate zones (Sakagami and Munakata 1972).

Himalayan apple growers could improve pollination by providing habitat for nests of *L.* (*E.*) *matianense* near their orchards. The trees should be grown on, or near, south-facing, sunny, turf-covered slopes, where vertical cuts have been made, to expose bare soil banks for nesting bees.

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A NEW SPECIES OF *PSEUDONOMONEURA* BEQUAERT (DIPTERA: MYDIDAE) FROM MEXICO

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Abstract.—A new mydid fly, ***Pseudonomoneura calderwoodi*, n. sp.**, is described and illustrated from 18 specimens collected in Baja California, Mexico. This species is most similar to *Pseudonomoneura nelsoni* Fitzgerald and Kondratieff, and the characters for their separation are summarized. The existing taxonomic key to species of *Pseudonomoneura* is modified to accomodate the new species.

Key Words: Mydidae, *Pseudonomoneura*, Mexico

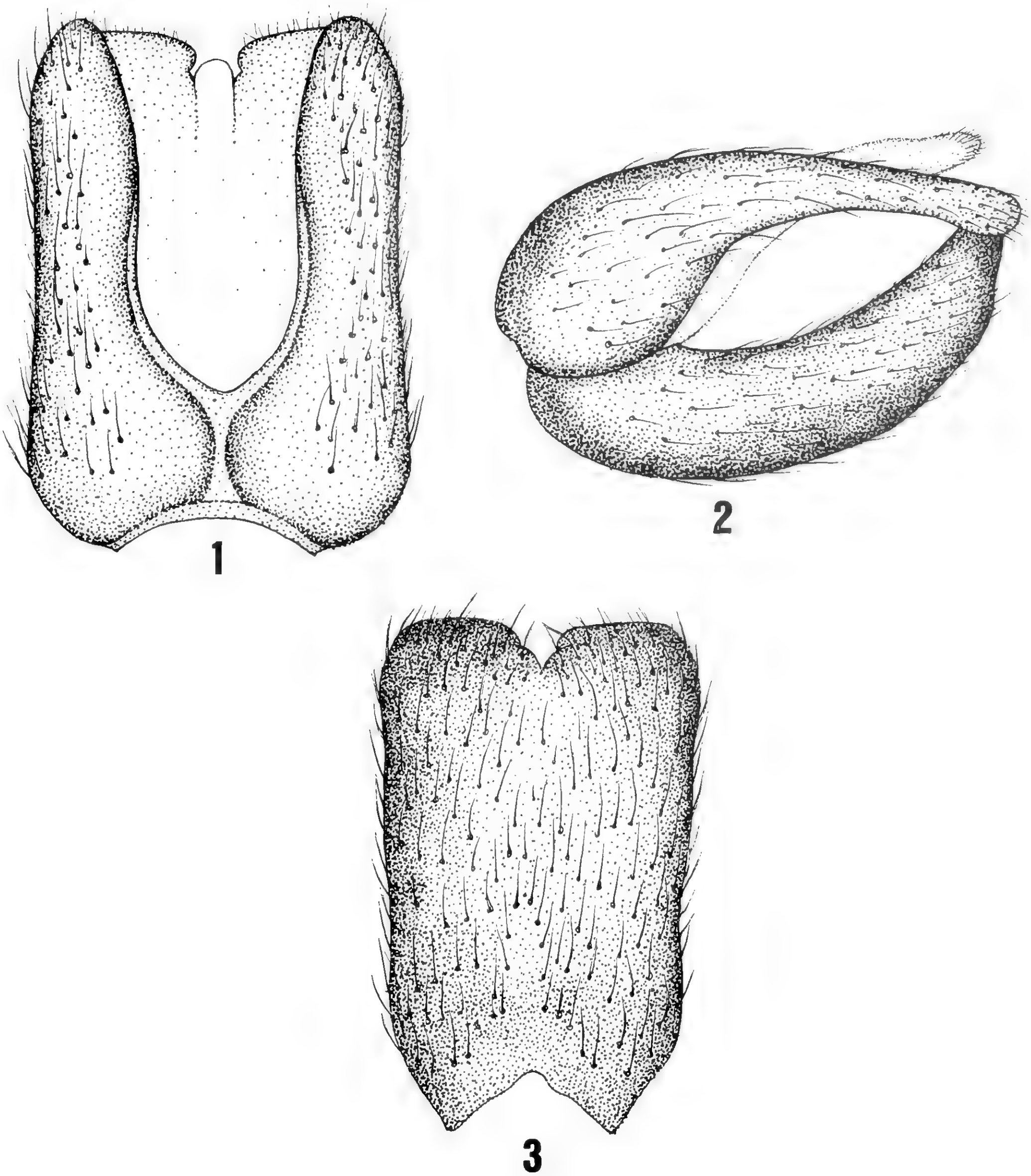
Fitzgerald and Kondratieff (1995) provided a recent review of the mydid fly genus *Pseudonomoneura* Bequaert in which six species are recognized. Through the kindness of J. A. Calderwood, Santa Barbara Museum of Natural History, 18 males of *Pseudonomoneura* which represented a new species were made available to us for description.

Terminology of male terminalia follows Fitzgerald and Kondratieff (1995). Abbreviations for depositories of specimens are: California Academy of Sciences, San Francisco (CAS); C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins (CSU); J. A. Calderwood Collection, Santa Barbara, California (JAC); Santa Barbara Museum of Natural History, Santa Barbara, California (SBMN).

Pseudonomoneura calderwoodi Fitzgerald and Kondratieff, New Species
(Figs. 1–3)

Types.—*Holotype:* ♂ (CAS), Mexico: Baja California [Baja California Norte], 13 km North of Guerrero Negro, dunes, 13 April 1995, J. A. Calderwood. *Paratypes:* same data as holotype, 5 ♂ (CAS), 5 ♂ (CSU), 3 ♂ (JAC), 4 ♂ (SBMN).

Description.—*Male:* Head: Frons densely silver-white tomentose and pilose. Occiput black. Antenna short, stout, brown to black with sparse white pile on pedicel and scape. Mouthparts vestigial. Thorax: Mesonotum densely silver-white tomentose with three opaque gray-brown tomentose vittae. Lateral vittae narrower and shorter than medial vitta. Mesonotum densely silver-white pilose except on vittae. Pleurae shining brown with some areas of silver-white tomentum. Halter yellow-white. Scutellum silver-white tomentose. Legs: Light brown with femora darker than tibiae and tarsi. Hind leg with light brown hair and weakly developed flexor spines. Hind femur not swollen. Wing: Hyaline, 5–6.5 mm, venation as in other *Pseudonomoneura*. Abdomen: Tergites brown in ground color with yellow-white posterior margins. All tergites with thin silver-white tomentum and decumbent pile except on a middorsal longitudinal brown vitta which runs length of abdomen. Sternites brown with sparse decumbent pile. Bullae small, dark brown. Genitalia: In dorsal view, upper forceps of epandrium slender, apically rounded (Fig.



Figs. 1–3. *Pseudonomoneura* calderwoodi, male terminalia. 1, Dorsal view. 2, Lateral view. 3, Ventral view.

1), in lateral view, apically truncate, simple (Fig. 2). Gonocoxites slightly cleft with ventral processes absent (Fig. 3).

Female: Unknown.

Etymology.—The patronym honors Mr. J. A. Calderwood (SBMN), who collected and made available specimens for description.

Diagnosis.—The vestigial mouthparts and the simple form of the upper forceps of the epandrium (i.e. lacking the digitate structure of *P. californica* (Hardy), the bifurcate structure of *P. bajaensis* Fitzgerald and Kondratieff, or the upper and lower flanges of *P. hirta* (Coquillett), *P. micheneri* (James) and *P. tinkhami* (Hardy)) will easily separate males of *P. calderwoodi* from all other *Pseudonomoneura*, with the exception of *P. nelsoni* Fitzgerald and Kondratieff. Males of *P. calderwoodi* can be distinguished from the similar *P. nelsoni*, by the genitalia in dorsal view which have the upper forceps of the epandrium apically rounded (Fig. 1), rather than apically acute and bent outward (see Fitzgerald and Kondratieff 1995: 32, Fig. 21). In lateral view, the upper forceps of the epandrium are more apically truncate (Fig. 2) than in *P. nelsoni* (see Fitzgerald and Kondratieff 1995: 32, Fig. 20).

Males of *P. calderwoodi* can be identified using the key of Fitzgerald and Kondratieff (1995) with the following modification of couplets 1 and 2 (figure numbers are those in Fitzgerald and Kondratieff 1995):

1. Mouthparts vestigial 2
– Mouthparts well-developed 3
2. Male terminalia with upper forceps of epandrium simple (Figs. 20, 21) 2a
– Male terminalia with upper forceps of epandrium bifurcate (Figs. 17, 18) . . . . *bajaensis*
2a. Upper forceps of epandrium apically acute and bent outward in dorsal view (Fig. 21) . . . . *nelsoni*
– Upper forceps of epandrium apically rounded and not bent outward in dorsal view . . . . *calderwoodi*, n. sp.

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REPORT ON A COLLECTION OF BETHYLIDAE (HYMENOPTERA) FROM CENTRAL FLORIDA

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Abstract.—About 3200 specimens representing 51 species of Bethylidae were taken, primarily in Malaise traps, at 5 sites in Orange Co., and one site in Seminole Co., Florida. These are listed, with habitats and dates of collection. One new species is described: ***Bakeriella mira* Evans**. Range extensions are indicated for four species, and one new synonymy is made.

Key Words: Hymenoptera, Bethylidae, wasps, Florida

Beginning in 1990, biologists at the University of Central Florida (UCF) have surveyed the arthropod fauna of the campus, using Malaise traps and a variety of other sampling techniques. The university was founded in 1963 on an 1100 acre plot of land that had previously been a cattle ranch. Malaise traps were set up in four ecologically distinct sites on campus and were maintained throughout the year, being emptied every 4–5 days. Specimens were collected in cyanide prior to 1995, in that year and 1996 in 70% isopropyl alcohol. Traps were of the design of Townes (1972) with some modifications. Fine-meshed cloth was used, in some cases all black, in others black and white. Two Malaise traps were also set up outside the campus, one at Rock Springs Run State Reserve, 40 km NW of the UCF campus, and one at the home of SMF in Oviedo, 9 km N of the campus. The last locality is in Seminole Co., the others in Orange Co.

A report on the Bethylidae seems justified because of the large number of specimens taken (3200) and the diversity of the fauna (51 species). Some species occurred in remarkable numbers, for example 817 males and 9 females of *Pseudisobrachium flaviventre* (Kieffer). Such figures suggest that some Bethylidae are much more plentiful than commonly realized. To the best of our knowledge, no species of *Pseudisobrachium* has ever been reared from a host. Females have been found in ant nests, but it is uncertain whether they attack the larvae of ants or of their beetle myrmecophiles. Clearly there is much room for research.

The collection includes one previously undescribed species and four range extensions, two of them unexpected reports of species of more tropical distribution. One new synonymy is made on the basis of series of males and females formerly assigned to different species.

COLLECTION SITES

The collection sites are referred to by number in the list that follows.

1. A disturbed area of long leaf and slash pine (*Pinus palustris* Mill. and *P. elliottii* Engelm.), turkey oak (*Quercus laevis* Walter), and saw palmetto (*Serenoa repens*

(Bartr.). This site has not been burned for many years and now bears many sand pines, *Pinus clausa* (Engelm.) Sarg. UCF campus.

2. A scrub growing on fossil sand dunes with vegetation that includes sand pine, Florida rosemary (*Ceratiola ericoides* Michx.), saw palmetto, and scrub oaks (*Quercus geminata* Small, *Q. myrtifolia* Willd., and *Q. chapmani* Sargent, in order of abundance), and lyonias, *Lyonia ferruginea* (Walt.) Nutt. and *L. lucida* (Lam.) Koch. UCF campus.

3. Cypress dome, consisting of pond cypress (*Taxodium ascendens* Brogn.), maidencane (*Panicum hemitomon* Schultes), wax myrtle (*Myrica cerifera* L.), dahoon holly (*Ilex cassine* L.), and gallberry (*Ilex glabra* L.). The trap was about 3 m out in the water at the middle of the cypress ring. UCF campus.

4. Site near a nyssa pond (*Nyssa sylvatica* Marsh) that was wet for a large part of the year; an area adjacent to the site has since been developed as a retention pond. Vegetation consists of long leaf and slash pine, saw palmetto, shining lyonia, *Lyonia lucida* (Lam.) Koch, and assorted grasses. UCF campus.

5. Rock Springs Run State Reserve. This is a 356 acre parcel of land that has not been burned within the last 40-50 years. Predominant vegetation is sand pine and sand live oak (*Quercus geminata* Small), with a secondary mixture of myrtle oak (*Q. myrtifolia* Willd.), Chapman's oak (*Q. chapmani* Sargent), saw palmetto, and Florida rosemary.

6. A rural yard in an older neighborhood of Oviedo. One side of the trap faced a moderately cultivated yard, with weeds and a mixture of native and exotic plants; the other side faced an abandoned field that was once a citrus orchard.

LIST OF SPECIES

Listing of genera follows Evans (1978), with species of each genus listed alphabetically.

SUBFAMILY PRISTOCERINAE

Pristocera armifera (Say). 7 ♀♀, 87 ♂♂. May–Dec. Sites 1, 2, 4.

P. atra Klug. 2 ♀♀, 218 ♂♂. Throughout the year. Sites 1, 2, 5.

P. bridwelli Evans. 1 ♂. June. Site 1. New record for Florida.

P. fraterna Evans. 7 ♀♀, 142 ♂♂. Throughout the year, all sites.

Apenesia parapolita (Evans). 2 ♀♀, 30 ♂♂. Throughout the year. Sites 1, 2, 5.

Dissomphalus apertus Kieffer. 21 ♂♂. May–Sept. Sites 3, 4.

D. barberi Evans. 1 ♂. Oct. Site 6. New record for Florida.

D. kansanus Evans. 1 ♂. Oct. Site 1.

Pseudisobrachium arenarium Evans. 807 ♂♂. Throughout the year. Sites 1, 2, 5, 6. See note below.

P. ashmeadi Evans. 73 ♂♂. Jan.–Feb., June–Dec. Sites 1, 2, 4, 5, 6.

P. carolinianum Evans. 59 ♂♂. Jan., June–Nov. Site 5.

P. flaviventre (Kieffer). 9 ♀♀, 817 ♂♂. Throughout the year. Sites 1, 2, 4, 6. See note below.

P. rufiventre (Ashmead). 49 ♂♂. Jan., Apr.–Dec. Sites 1, 2, 5, 6.

SUBFAMILY EPYRINAE

Rhabdepyris amabilis Fouts. 5 ♂♂. May–Aug. Sites 2, 4, 5.

R. carolinianus Evans. 8 ♀♀, 35 ♂♂. May–Sept. Sites 1, 2.

R. mellipes Evans. 1 ♀. May. Site 4.

R. muesebecki Evans. 3 ♂♂. June, July. Sites 1, 3.

Anisepyris analis (Cresson). 59 ♀♀, 29 ♂♂. Jan.–Nov. Sites 1, 2, 4, 5, 6.

A. bradleyi (Evans). 1 ♀. July. Site 2.

A. columbianus (Ashmead). 6 ♀♀, 18 ♂♂. Jan., Apr.–Aug. Sites 1, 2, 5.

A. gibbosifrons Evans. 1 ♂. June. Site 6. Flight intercept trap.

A. grandis (Ashmead). 31 ♀♀, 210 ♂♂. Throughout the year. All six sites.

A. subviolaceus Kieffer. 1 ♀, 8 ♂♂. May–Aug. Sites 1, 2, 4, 5.

Epyris alachua Evans. 4 ♀♀. Mar., May, July. Sites 2, 6.

E. deficiens Krombein. 4 ♀♀, 20 ♂♂. Throughout the year. Sites 1, 2, 5.

E. festivus Evans. 29 ♀♀, 24 ♂♂. Throughout the year. Sites 1, 2, 3, 5. See note below.

E. myrmecophilus (Brues). 1 ♀, 13 ♂♂. Throughout the year. Sites 1, 2.

E. oriplanus Kieffer. 1 ♀, 2 ♂♂. May, July, Dec. Sites 1, 2.

E. rufipes (Say). 39 ♀♀, 182 ♂♂. Throughout the year. All six sites.

E. spissus Evans. 20 ♀♀, 6 ♂♂. Throughout the year. Sites 1, 2, 3.

E. tricostatus Evans. 1 ♀, 1 ♂. July, Aug. Sites 1, 2.

Bakeriella mira Evans, n. sp. described below. 2 ♂♂. June, July. Site 1.

Holepyris floridanus (Ashmead). 3 ♀♀, 18 ♂♂. Throughout the year. Sites 1, 2, 5, 6.

H. graminis Evans. 1 ♀, 7 ♂♂. Jan., June–Nov. Sites 1, 2, 4, 5, 6.

H. hispaniolae Evans. 3 ♀♀, 1 ♂. Apr.–July. Sites 1, 2, 5. Two ♀♀ taken in flight intercept trap. See note below.

H. lautus Evans. 1 ♀, 21 ♂♂. Throughout the year. Sites 1, 2, 4, 5, 6.

H. micidus Evans. 2 ♀♀, 9 ♂♂. May, July–Dec. Sites 1, 2, 6.

H. subapterus (Melander and Brues). 2 ♀♀. May. Site 2.

H. subtilis Evans. 1 ♀, 3 ♂♂. May, Aug., Sept. Sites 1, 2, 3. ♀ taken in flight intercept trap. See note below.

Laelius centratus (Say). 1 ♀. April. Site 6.

Scleroderma macrogaster (Ashmead). 3 ♀♀. Apr.–May. Site 6.

SUBFAMILY BETHYLINAE

Prosierola bicarinata (Brues). 1 ♀. July. Site 6.

Goniozus columbianus Ashmead. 1 ♀. Feb. Site 4.

G. floridanus (Ashmead). 1 ♀. Aug. Site 2.

G. fratellus Evans. 2 ♀♀. Mar., Oct. Site 2.

G. hortorum Brues. 3 ♀♀. Mar., May, Aug. Sites 1, 4.

G. hubbardi Howard. 6 ♀♀. Feb., Mar., June, Dec. Sites 1, 4, 6.

G. indigens Evans. 5 ♀♀. May. Site 2. Flight intercept trap.

G. nigrifemur Ashmead. 10 ♀♀. Feb., Mar., May, Sept., Oct. Sites 1, 2, 3, 6.

G. scitulus Evans. 3 ♀♀. Apr., Aug., Oct. Sites 2, 6.

G. seminole Evans. 9 ♀♀. Jan., Feb., Apr., June–Nov. Sites 2, 4, 5.

NOTES AND DESCRIPTIONS OF INDIVIDUAL SPECIES

Pseudisobrachium arenarium Evans

This species is a member of the *prolongatum* group of Evans (1961), in which the mandibles of the male are 5-toothed, but the third and fourth teeth are very small and may be partially or even wholly fused, resulting in 4-toothed mandibles. Of the 807 males collected in this study, 233 (29%) have only four distinct mandibular teeth. These are mainly smaller males and are easily confused with *rufiventre*. However, in *arenarium* the minimum width of the frons barely if at all exceeds eye height and the antennae are more elongate, segment 3 being about twice as long as wide.

Pseudisobrachium flaviventre (Kieffer)

Correct association of the sexes in this genus is difficult, as males are commonly taken sweeping, in traps, or at light, while females are usually found in ant nests. In this case the 9 females may have been carried into malaise traps by males through phoretic copulation, as is known to occur in other Pristocerinae. These females are minute, varying in body length from 2 to 3 mm, in head length from 0.40 to 0.53 mm; length of the head varies from 1.25 to 1.42 times width of the head. This stands in contrast to the female *rufiventre*, in which the head is 0.68 to 0.8 mm long and 1.1 to 1.2 times as long as wide. The mandibles of the 9 *flaviventre* females are basically bidentate, but in 5 specimens a small knob basad of the uppermost tooth can be detected, and in 2 a small third tooth is present. By and large, these specimens key well to *flaviventre* in the keys to females presented by Evans (1961, 1978).

Some of the characters previously used for identification of males have proved of doubtful reliability. The most useful feature for identifying male *flaviventre* is the compact, pale yellowish to reddish-brown antennae, in which the outer flagellar segments (except the last) are no longer than wide. In contrast, male *rufiventre* have brown antennae in which the outer flagellar segments are distinctly longer than wide.

Epyris festivus Evans

This is a member of the *depressigaster* group of Evans (1969), in which the abdomen of the female is strongly depressed and bears one or more hyaline plates ventrally. In characterizing the group, Evans suggested the possibility that members of the *idionotum* group might represent the male sex. Collection of 29 females of *festivus* and 24 males of *idionotum* at similar times and sites makes it clear that these are female and male of one species. While pronotal structure is very different, there is similarity in the dark olive-green coloration as well as in the 9 or 10 parallel propodeal carinae. This is a new synonymy, *festivus* having page priority over *idionotum*; both were described by Evans in 1969.

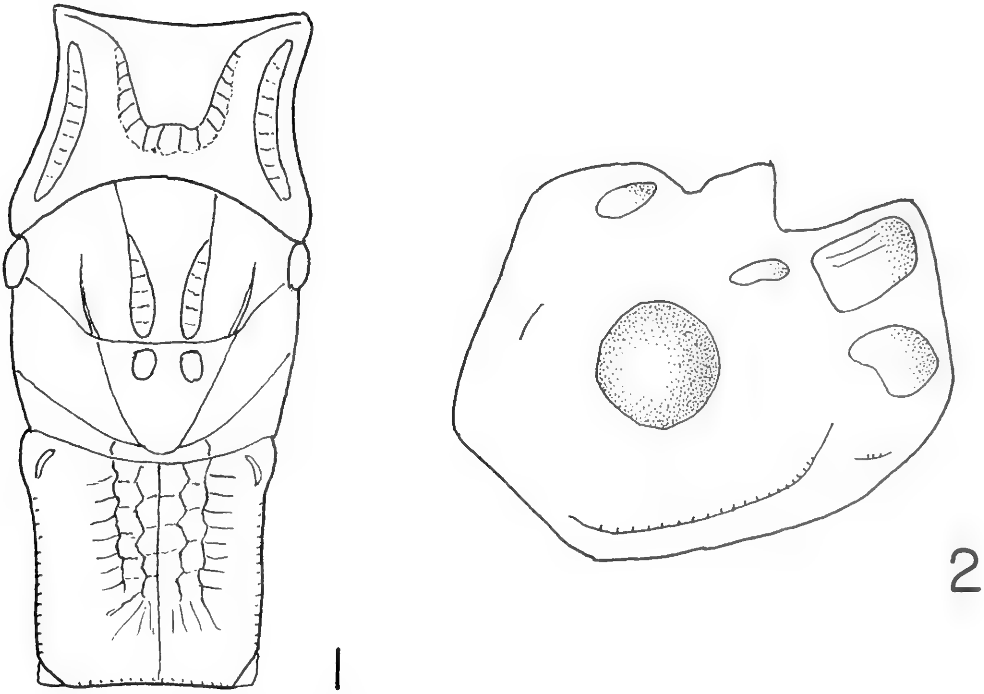
***Bakeriella mira* Evans, new species**

Holotype.—♂, FLORIDA: Orange Co., UCF, Orlando, VII-22-93; LLP-sand pine, turkey oak; Malaise trap, S.M. Fullerton collector (National Museum of Natural History, Smithsonian Institution). *Paratype*.—♂, same data except collected VI-7-96 (Florida State Collection of Arthropods).

Description of holotype male.—Length 4.2 mm, fore wing 2.7 mm. Black; antenna bright reddish-brown, apical two segments darkened; palpi light brown; mandible black basally, reddish apically; tegula light brown; coxae and mid and hind femora black, fore femur and all tibiae and tarsi brown; wings hyaline. Median lobe of clypeus obtusely angulate; antennal scrobes not carinate; genae not carinate. Scape about twice as long as thick; first 4 antennal segments in a ratio of 17:7:7:10. Head about as wide as high; eyes weakly convergent below, not hairy; width of frons 0.58 times width of head, 1.10 times height of eye. Ocelli in a right triangle, ocello-ocular line subequal to width of ocellar triangle. Frons weakly shining, alutaceous, with small, setigerous punctures separated by somewhat more than their own diameters.

Thoracic dorsum similarly alutaceous and punctate, bearing short, brown hairs. Pronotum with anterior lateral angles sharp and slightly protuberant; lateral margins concave, paralleled internally by a foveolate groove; anterior margin of disc elevated, the elevation extended broadly backward, then slightly emarginate, margins of the elevation foveolate; posterior pronotal margin simple (Fig. 1). Mesoscutum with deeply impressed, somewhat foveolate notauli that are progressively more slender anteriorly, reaching the pronotum as thin lines. Scutellum flat, with two large pits separated by slightly less than their own diameters. Propodeal disc 1.15 times as wide as long, with a complete median carina flanked by 4 incomplete, more irregular carinae between which the surface is foveolate; sides of disc weakly transversely striate, posterior margin carinate. Mesopleurum with a large, bowl-shaped median pit and two smaller anterior pits; lower margin with a weakly foveolate longitudinal carina (Fig. 2).

Variation.—The paratype is slightly larger than the type, body length measuring 4.9 mm, fore wing 2.9 mm. Resemblance to the type is very close, but there are two minor differences in sculpturing: the scutellar pits are not quite as wide and are separated by approximately their greatest diameters; and there are only 3 well-defined propodeal carinae, the 2 irregular carinae close beside the median carina being less well formed than in the type.



Figs. 1, 2. *Bakeriella mira*, holotype. 1, Dorsal aspect of thorax and propodeum. 2, Lateral aspect of mesopleurum, anterior margin to the right. Figures not drawn to same scale.

Remarks.—This striking species is known from only two specimens. The form of the anterior elevation of the pronotum is unique in the genus. Well separated scutellar pits such as those in *mira* occur in only one other known species of *Bakeriella*, *cristata* Evans, known from Brazil, Bolivia, and Argentina (Evans, 1964, 1979). Only one other species of *Bakeriella* is known from the United States: *floridana* Evans, reported from Dade Co., Florida, also from Jamaica. This species differs in many details from *mira*: the scutellar pits are separated by a thin septum, the pronotum has a transverse carina across the front, and the mesopleurum lacks a large median depression.

Twenty-three species of this neotropical genus are now known. Evans (1979) provided a key for 18 of these. Azevedo (1991, 1994) has recently added three species of *Bakeriella* from Brazil and presented a key to the 11 species having an anterior transverse carina on the pronotum.

Holepyris hispaniolae Evans

This species was described by Evans (1977) from a single female from Constanza, Dominican Republic. Three females from sites 2 and 5 agree very closely with the type and represent a notable range extension—not however without precedent, since *Bakeriella floridana* Evans and *Anisepyris aurichalceus* (Westwood) also occur both in Florida and in the West Indies. A male from site 1 almost certainly represents the previously unknown male of this species. In the key of Evans (1958) it runs to *floridanus* (Ashmead) but the prominently 5-carinate propodeum (similar to that of the female) and the broader head distinguish it readily. The head is about as wide as high; width of the frons is 0.61 times width of the head, 1.27 times height of the eye. The antennae are wholly brown, the coxae black, femora light brown, tibiae and tarsi testaceous.

Holepyris subtilis Evans

This species was described from Costa Rica and Panama, with a single female from southern California and a single male from southern Arizona (Evans, 1978). It is a distinctive species, males lacking erect pubescence on the flagellum and having 5 propodeal carinae with two shorter carinae laterad of these. Females are one of only two American species lacking a transverse pronotal carina; the frons is unusually narrow, the minimum width in this instance only 0.70 times the eye height; the antennal scape is fully 6.5 times as long as thick. Three males from sites 1 and 3 and a female from site 2 represent a major range extension for this species.

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LIFE HISTORY AND DESCRIPTION OF IMMATURE STAGES OF *PROCECIDOCHARES ANTHRACINA* (DOANE) (DIPTERA: TEPHRITIDAE) ON *SOLIDAGO CALIFORNICA* NUTTALL IN SOUTHERN CALIFORNIA

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Abstract.—*Procecidochares anthracina* (Doane) is a univoltine, circumnatal, tephritid fly widely distributed in the western United States and apparently nearly monophagous on *Solidago californica* Nuttall and as yet unknown congeners probably of similar growth habit. Unique among other *Procecidochares* species studied to date, *P. anthracina* reproduces gregariously in underground bud galls on shoots arising from host-plant rhizomes. The egg, first through third instars, and puparium are described and figured for the first time. The small, rounded, rugose pads that circumscribe the prothorax; the presence of four, small subdorsal sensilla ventrolaterad of the dorsal sensory organ and dorsal to the anterior sensory lobe, and the lateral spiracular complexes distinguish the third instar from other gallicolous *Procecidochares* examined to date. Pupariation occurs within subsurface galls and teneral adults must climb upward through several cm of humus to free themselves and mate. Premating, mating, and postmating behaviors are described which include spurts of exceptionally rapid, blurred wing enantions. Mated females must reenter the humus layer to oviposit in buds on buried shoots, as subsequently must parasitoids to locate and probably enter galls to oviposit in the larvae or puparia. *Eurytoma obtusiventrus* Gahan (Hymenoptera: Eurytomidae) is reported as a solitary, larval-pupal endoparasitoid reared from puparia; *Pronotalia carlinarium* Gradwell (Hymenoptera: Eulophidae) is a gregarious endoparasitoid of puparia.

Key Words: Insecta, *Procecidochares, Solidago,* biology, galls, taxonomy of immature stages, reproductive behavior, parasitoids

Life histories and immature stages of four species of *Procecidochares* (Diptera: Tephritidae) in southern California have been described to date, i.e. *P. flavipes* Aldrich (Goeden et al. 1994a), *P. kristineae* Goeden (Silverman and Goeden 1980, Goeden and Teerink 1997), *P. lisae* Goeden (Goeden and Teerink 1997), and *P. stonei* Blanc and Foote (Green et al. 1993). Herein we describe the life history and immature stages of a fifth species, *P. anthracina* (Doane), which uniquely forms bud galls on shoots arising from subsurface rhizomes of *Solidago californica* Nuttall (Asteraceae).

MATERIALS AND METHODS

Our field studies on *P. anthracina* were conducted principally at two locations in southern California during 1992-1995: (1) at the junction of Kitchen Creek Road and the Sunrise Highway at 1720-m elevation, Cleveland National Forest, San Diego Co. and (2) in Spilman Canyon SE of Lake Hemet at 1380 m, San Bernardino National Forest (S section), Riverside Co. Infested rootstocks dug from humus beneath deciduous oaks (*Quercus* spp.) within patches of shoots of *Solidago californica* were transported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement. Twenty six eggs dissected from buds and seven first-, 12 second-, and 14 third-instar larvae, and six puparia from galls were preserved in 70% EtOH for scanning electron microscopy (SEM). Additional puparia were placed in separate, glass shell vials stoppered with absorbant cotton and held in humidity chambers at room temperature for adult and parasitoid emergence. Specimens for SEM were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH and two, 1-h immersions in Hexamethlydisilazane (HMDS), mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia obtained from galls were individually caged with excavated rhizome fragments attached or unattached to basal portions of aerial shoots in 850-ml, clear-plastic, screened-top cages with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. Those cagings without rhizome bouquets were used for longevity studies and those with bouquets for oviposition tests in the insectary of the Department of Entomology, University of California, Riverside, at 25 ± 1°C, and 14/10 (L/D) photoperiod. Virgin male and female flies obtained from emergence vials were paired in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey (Headrick and Goeden 1991) for direct observations, videorecording, and still-photography of their courtship and copulation behavior.

Plant names used in this paper follow Munz (1974); tephritid names and nomenclature follow Foote et al. (1993). Terminology and telegraphic format used to describe the immature stages follow Goeden et al. (1993; 1994a, b; 1995a, b) and Goeden and Teerink (1996a, b, c; 1997) and our earlier works cited therein. Means ± SE are used throughout this paper. Voucher specimens of *P. anthracina* and its parasitoids reside in the research collections of RDG; preserved specimens of eggs, larvae and puparia are stored in a separate collection of immature Tephritidae maintained by JAT.

RESULTS AND DISCUSSION

TAXONOMY

Adult.—First described by Doane (1899) as *Oedaspis anthracina*, then transferred to *Cecidochares* by Bezzi (1910), *P. anthracina* was assigned its current name by Bezzi and Tavares (1916) (Foote et al. 1993). Only the wing pattern of the adult has been figured by Doane (1899), Foote and Blanc (1963), and Foote et al. (1993). Adults are separated from other congeners, and ultimately from *P. australis* Aldrich and *P. grindeliae* Aldrich, which this species most closely resembles, by the characters incorporated in the key to North American *Procecidochares* in Foote et al. (1993).

Immature stages.—Egg: Twenty eggs of *P. anthracina* were white, opaque, smooth; with an elongate-ellipsoidal body, 0.51 ± 0.005 (range, 0.47–0.54) mm long, 0.14 ± 0.002 (range, 0.13–0.19) mm wide, smoothly rounded at tapered posterior end (Fig. 1A), and with a peg-like anterior pedicel, 0.02 mm long and a few, large aeropyles (Fig. 1B). The egg of *P. anthracina* is similar in shape but smaller than *P. flavipes* (Goeden et al. 1994a) and *P. lisae* (Goeden and Teerink 1997). *Procecidochares stonei* (Green et al. 1993) and *P. kristineae* (Silverman and Goeden 1980, Goeden and Teerink 1997) eggs are smaller than *P. anthracina* eggs and have a tapered pedicel with much smaller, oval aeropyles.

Third instar: Third instar of *P. anthracina* superficially smooth, elongate cylindrical, tapering anteriorly, rounded posteriorly (Fig. 2A); gnathocephalon conical,

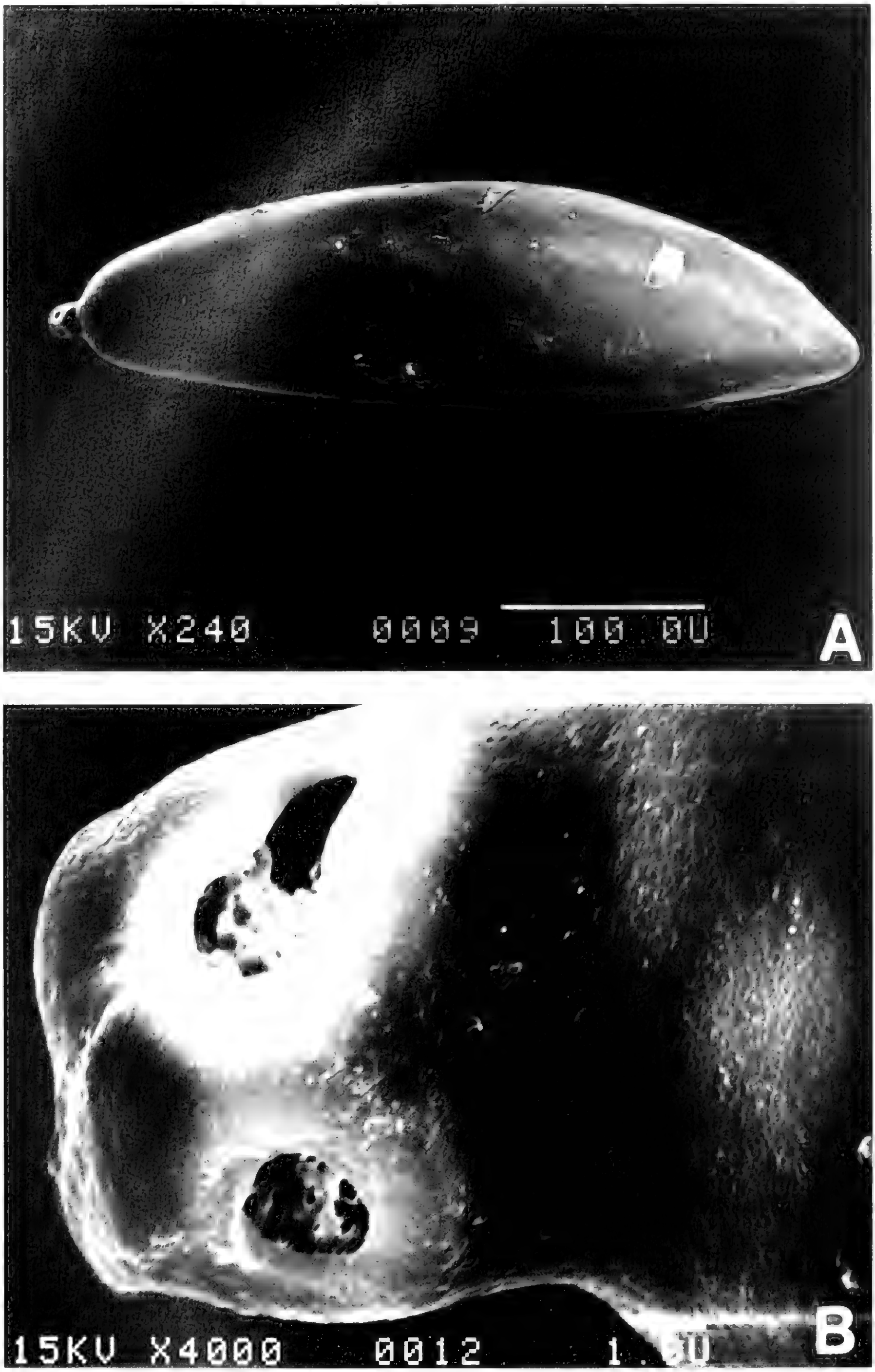

Fig. 1. Egg of *Procecidochares anthracina*. (A) habitus; (B) anterior end, aeropyles.

smooth, lacking rugose pads (Fig. 2B); paired dorsal sensory organs consist of a dome-shaped papilla (Fig. 2C-1); four, small, dome-shaped sensilla, each with a central papilla, located ventrolaterad of dorsal sensory organ (Fig. 2C-2); anterior sensory lobe bears the terminal sensory organ (Fig. 2C-3), pit sensory organ (Fig. 2C-4), lateral sensory organ (Fig. 2C-5) and supralateral sensory organ (Fig. 2C-6); stomal sense organs distinct, composed of raised lobe with two pore sensilla, ventrad of anterior sensory lobes (Fig. 2D-1); lateral sensilla laterad of stomal sense organ (Fig. 2D-2), two of eight verruciform sensilla, including ventrolateral sensilla, circumscribing gnathocephalon (Fig. 2B-1); mouth hooks tridentate, teeth conical (Fig. 2B-2, D-3); median oral lobe obscured in prepared specimens; prothorax covered anteriorly with small, rounded rugose pads (Fig. 2B-3); verruciform sensilla posterior to rugose pads on dorsal half of prothorax (Fig. 2B-4); anterior spiracles on posterior margin of prothorax consist of two dome-shaped papillae (Fig. 2E); meso- and metathoracic lateral spiracular complexes consist of an open spiracle and two verruciform sensilla; abdominal lateral spiracular complexes with an open spiracle (Fig. 2F-1) and one verruciform sensillum (Fig. 2F-2); caudal segment smooth (Fig. 2G-1); posterior spiracular plates with three ovoid rimae, ca. 0.03 mm in length (Fig. 2H-1), and four spiniform interspiracular processes, longest measuring 0.007 mm (Fig. 2H-2); compound sensilla ventrad of posterior spiracular plates consist of a stelex sensillum (Fig. 2G-2) and a verruciform sensillum (Fig. 2G-3).

The *P. anthracina* third instar differs from that of the flower head-infesting *P. flavipes* in that the mouth hooks are tridentate, the rugose pads are limited to the prothorax and no minute acanthae are present in the intersegmental areas nor on the caudal segment (Goeden et al. 1994a). *Procecidochares anthracina* more closely resembles the other gall-forming *Procecidochares* spp. we previously have examined, i.e., *P. kristineae, P. lisae* and *P. stonei,* but differs mainly in that its prothorax is circumscribed by small, rounded rugose pads; whereas, the other three gall-forming species lack these rugose pads (Goeden and Teerink 1997; Green et al. 1993). Differences also were noted in the lateral spiracular complexes; whereby, *P. kristineae* and *P. lisae* lack verruciform sensilla on the metathorax (Goeden and Teerink 1997), and the verruciform sensilla in *P. stonei* are anterior to the spiracle (Green et al. 1993). Several previously undescribed sensilla were found on the gnathocephalon of *P. anthracina.* Four small sensilla located ventrolaterad of the dorsal sensory organ and dorsad to the anterior sensory lobe are collectively named subdorsal sensilla, and are unreported among previously examined, nonfrugivorous Tephritidae (Goeden and Headrick 1990, 1991a, b, 1992; Goeden et al. 1993, 1994a, b, 1995a, b; Goeden and Teerink 1996a, b, c; Green et al. 1993; Headrick and Goeden 1990, 1991, 1993; Headrick et al. 1995). A single, subdorsal sensillum located laterad to the dorsal sensory organ was reported in *Trupanea nigricornis* and *T. bisetosa* (Knio et al. 1996) and *Dioxyna picciola* (Headrick et al. 1996).

Second instar: Second instar of *P. anthracina* superficially smooth, elongate cylindrical (Fig. 3A); gnathocephalon conical, smooth, lacking rugose pads (Fig. 3B); paired dorsal sensory organs each consist of a dome-shaped papilla (Fig. 3C-1); anterior sensory lobes (Fig. 3B-1) bear the terminal sensory organ (Fig. 3C-2), pit sensory organ (Fig. 3C-3), lateral sensory organ (Fig. 3C-4), and supralateral sensory organ (Fig. 3C-5); stomal sense organ ventrad of anterior sensory lobe (Fig. 3B-2); mouth hooks obscured, apical tooth conical (Fig. 3B-3); median oral lobe obscured in prepared specimens; prothorax covered anteriorly with small, rounded rugose pads; verruciform sensilla posterior to rugose pads on dorsal half of prothorax; anterior spiracles

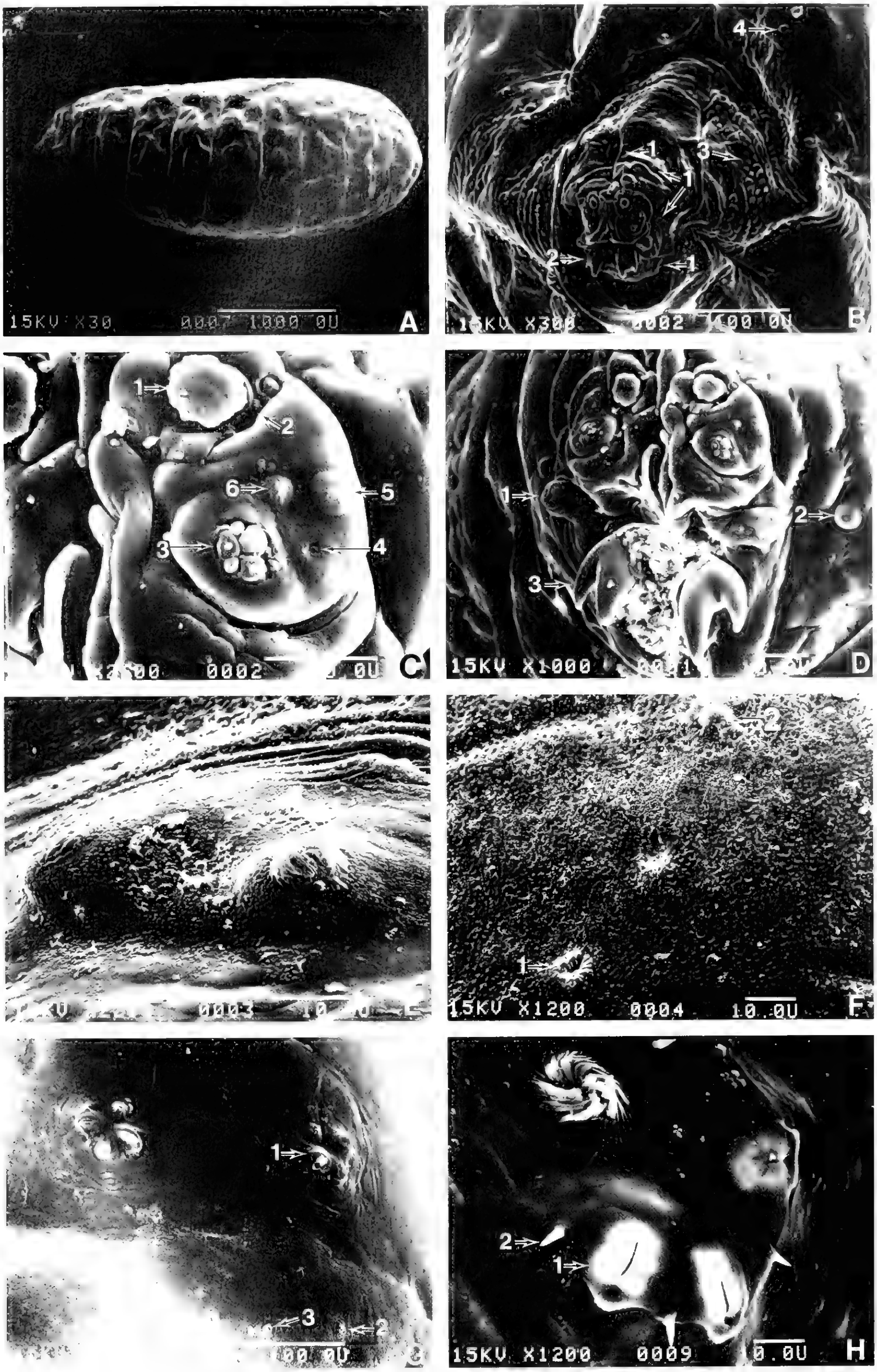

Fig. 2. Third instar of *Procecidochares anthracina*. (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—verruciform sensilla, 2—mouth hooks, 3—rugose pads, 4—prothoracic verruciform sensilla; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—subdorsal sensilla, 3—terminal sensory organ, 4—pit sensory organ, 5—lateral sensory organ, 6—supralateral sensory organ; (D) gnathocephalon, anterior view, 1—stomal sense organ, 2—lateral sensillum, 3—mouth hooks; (E) anterior spiracles; (F) fourth abdominal lateral spiracular

each consist of two dome-shaped papillae; lateral spiracular complexes not observed; caudal segment circumscribed by stelex sensilla (Fig. 3D-1); posterior spiracular plates bear three ovoid rimae, ca. 0.008 mm in length (Fig. 3D-2), and four spiniform interspiracular processes, longest measuring 0.005 mm (Fig. 3D-3); compound sensilla ventrad of spiracular plates consist of a stelex sensillum (Fig. 3D-4) and a verruciform sensillum (Fig. 3D-5).

Second instars of *P. anthracina* possess the same sensory structures as the mature larva, but the structures are not as well-defined. The mouth hooks, median oral lobe, and lateral spiracular complexes were obscured in prepared specimens.

First instar: First instars of *P. anthracina* cylindrical, rounded posteriorly, minute acanthae circumscribe segmental lines (Fig. 4A); gnathocephalon conical, smooth (Fig. 4B); dorsal sensory organ consists of dome-shaped papilla (Fig. 4B-1, C-1); anterior sensory lobe (Fig. 4B-2) bears terminal sensory organ (Fig. 4C-2), pit sensory organ (Fig. 4C-3), lateral sensory organ (Fig. 4C-4) and supralateral sensory organ (Fig. 4C-5); stomal sense organs ventrad of anterior sensory lobes indistinct (Fig. 4B-3); mouth hooks obscured in prepared specimens; anterior spiracles absent; lateral spiracular complexes not observed; caudal segment circumscribed by stelex sensilla (Fig. 4D-1); posterior spiracular plates bear two ovoid rimae, ca. 0.001 mm in length (Fig. 4D-2), and four rudimentary interspiracular processes, ca. 0.0003 mm in length (Fig. 4D-3).

The features of the first instar are less distinct than those of the mature larva. The first instar lacks the prothoracic rugose pads, but does have minute acanthae circumscribing the intersegmental lines not found in later instars. The anterior sensory lobes and dorsal sensory organs comprise most of the gnathocephalon. The four subdorsal sensilla are not present in the first instar. As the mouth hooks were obscured in all prepared specimens, we were unable to determine if the apical tooth was grooved as in *P. lisae* and *P. kristineae* (Goeden and Teerink, 1997). The respiratory system of the first instar was very reduced compared to both later instars. The posterior spiracular plates with two small rimae and the interspiracular processes were almost indistinct.

Puparium: Puparium of *P. anthracina* elongate ellipsoidal (Fig. 5A), anterior end bears the invagination scar (Fig. 5A-1), prothoracic rugose pads (Fig. 5B-2), verruciform sensilla (Fig. 5B-3) and anterior spiracles (Fig. 5B-4); caudal segment smooth, bears the posterior spiracular plates (Fig. 5C-1), and compound sensilla (Fig. 5C-2). One hundred and forty five puparia of *P. anthracina* averaged 3.56 ± 0.03 (range, 2.16–4.68) mm in length; 1.55 ± 0.02 (range, 0.94–1.99) mm in width.

DISTRIBUTION AND HOSTS

Because of its unusual reproduction on subsurface rootstocks and its widespread distribution in the western United States (Foote et al. 1993), where alternate hosts other than *S. californica* must occur, we believe that *P. anthracina* probably is nearly monophagous on *Solidago* spp. of similar growth habit. This assessment of its host affinities discounts the published "unpublished record" for an unidentified species of *Erigeron* in Wasbauer (1972) cited by Foote et al. (1993). *Erigeron* belongs to a different subtribe, Asterinae, of the tribe Solidagininae, than *Solidago* (Bremer 1994). Foote and Blanc (1963) reported a sweep

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complex, 1—spiracle, 2—verruciform sensillum; (G) caudal segment, 1—posterior spiracular plates, 2—compound sensillum, stelex sensillum, 3—compound sensillum, verruciform sensillum; (H) posterior spiracular plate, 1—rima, 2—interspiracular process.

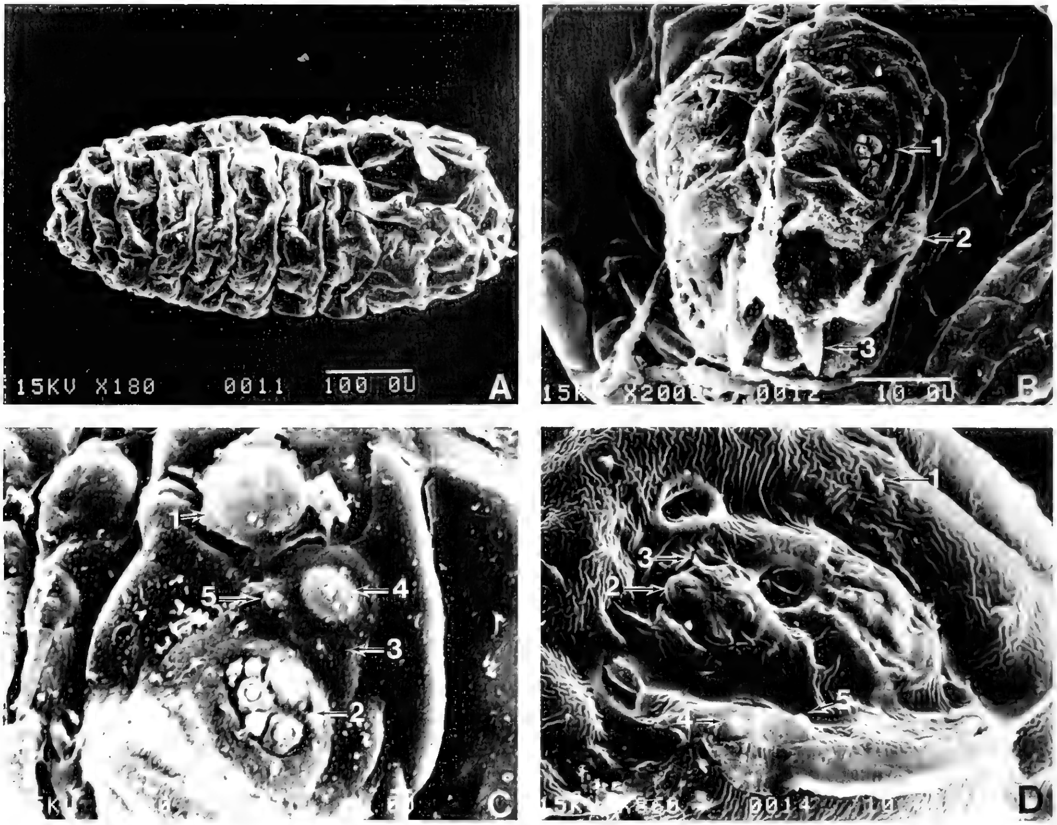

Fig. 3. Second instar of *Procecidochares anthracina*. (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—anterior sensory lobe, 2—stomal sense organ, 3—mouth hooks; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (D) caudal segment, 1—stelex sensillum, 2—rima, 3—interspiracular process, 4—compound sensillum, stelex sensillum, 5—compound sensillum, verruciform sensillum.

record from a *Chrysothamnus* sp., but that plant is a doubtful host of *P. anthracina*. Sweep records of adults all too often are misleading and suspect indicators of the host-plant affinities of nonfrugivorous tephritids. All four species of *Procecidochares* from southern California previously studied in similar detail as *P. anthracina* (Silverman and Goeden 1980, Green et al. 1993, Goeden et al. 1994a, Goeden and Teerink 1997) are strictly monophagous or nearly monophagous on congeneric hosts.

BIOLOGY

Egg.—Galls of *P. anthracina* were found on shoots arising from rhizomes of *Solidago californica* under crowns of deciduous oaks within a 3- to 10-cm deep surface layer of humus, i.e., decayed leaves, twigs, branches, and acorns; therefore, females must penetrate this loosely packed organic layer to reach the buried axillary buds within which the eggs are deposited (Fig. 6A, B). This behavior would require that females climb down the buried parts of vertical aerial shoots, or buried tree trunks, near to which galls most commonly were found. Females apparently may also follow farther along the horizontal rhizomes at the humus/mineral-soil interface and climb one or more vertical subsurface shoots to oviposit in the axillary buds. Alternatively, the females may sense and reach these buried shoots by penetrating the humus from di-

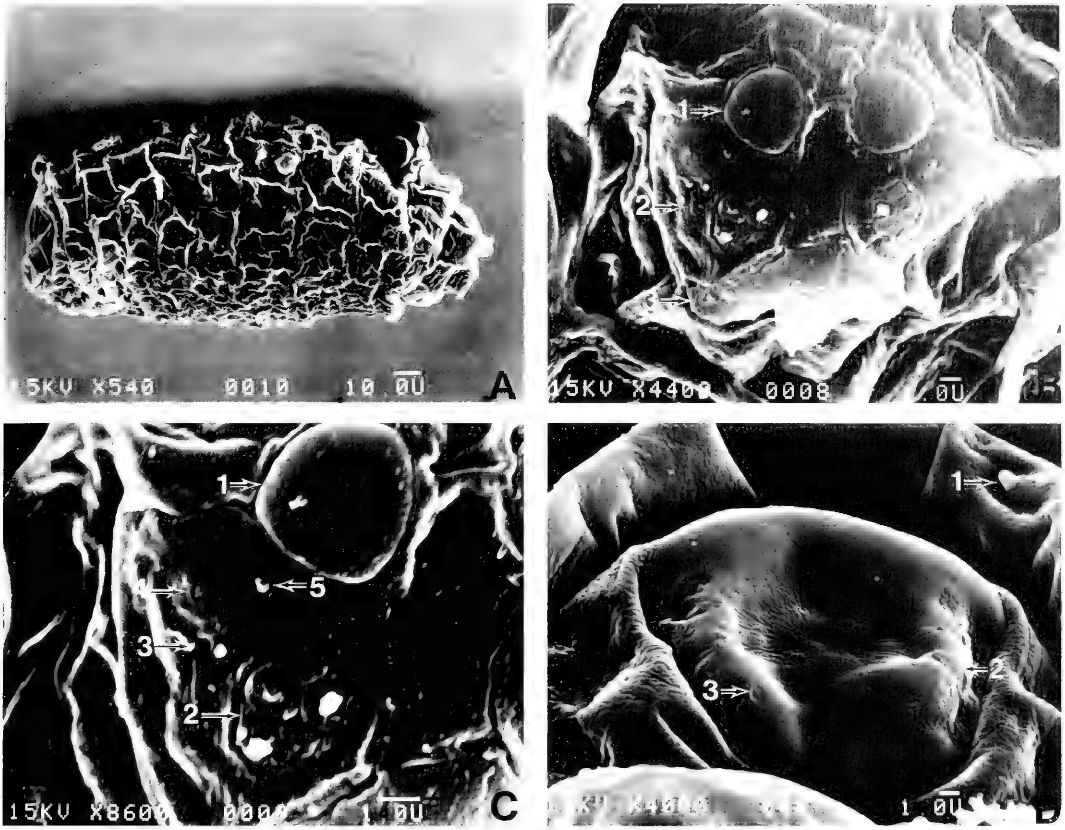

Fig. 4. First instar of *Procecidochares anthracina*. (A) habitus, anterior to right; (B) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—anterior sensory lobe, 3—stomal sense organ; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (D) caudal segment, 1—stelex sensillum, 2—rima, 3—interspiracular process.

rectly above (like a pig rooting for truffles), but this prcovipositional searching behavior seems less certain than using shoots and rhizomes as pathways. Ovipositing adults never were observed in nature, only in insectary cages (Fig. 6A).

The eggs were inserted pedicel upward, side-by-side, and lengthwise in bands within a prominent axillary bud, but not penetrating any tissue. Instead, the eggs were laid parallel to the long axis of the bud and stem, between an outer bract and bud, between the bud and stem, or among the leaf primordia (Fig. 6B). As many as 16 eggs were found in a single bud in nature; whereas, as many as 18 eggs were laid by one female in 1 day in an axillary bud in insectary cagings (Fig. 6A, B).

Larva.—Eggs hatch about a week after their deposition (Silverman and Goeden 1980, Green et al. 1993), but then the first instars persist, as these and later instars develop slowly through the fall, winter, and spring. The first instars initially develop gregariously by feeding within axils and buds in shallow, linear, surface scars (Fig. 6C). Some first instars move to adjacent axillary buds on the same shoot; others remain behind and feed gregariously within the original bud or divide into subgroups that subsequently each form separate galls that may arise from one axillary bud. Gall formation appears to result from larval activities, not maternal stimuli, as bud and stem swelling begins only after the larvae begin their surface feeding. Multiple gall

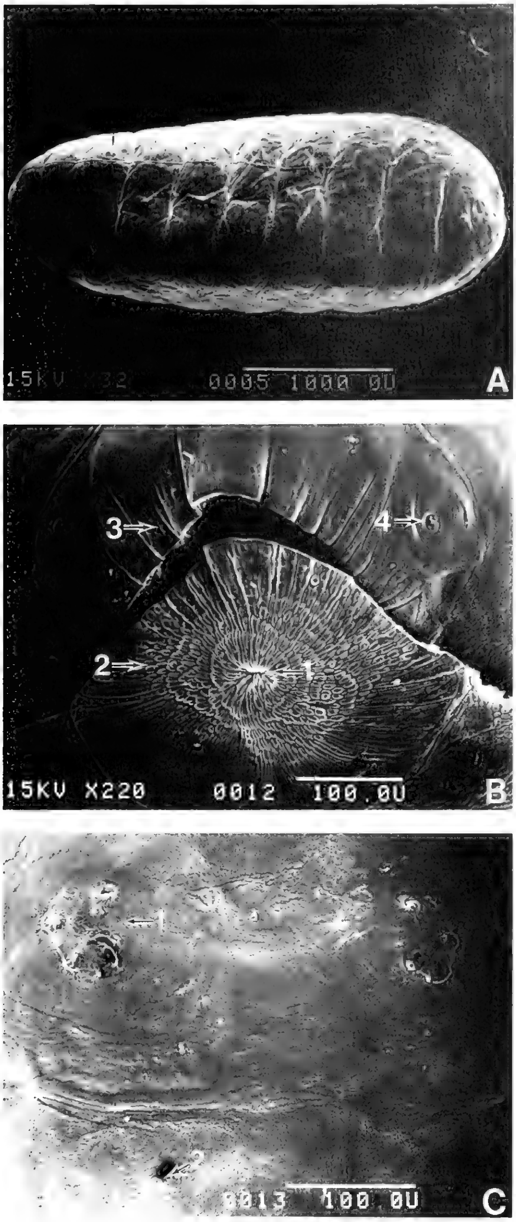

Fig. 5. Puparium of *Procecidochares anthracina*. (A) habitus, anterior to left; (B) anterior end, 1—invagination scar, 2—prothoracic rugose pads, 3—prothoracic verruciform sensilla, 4—anterior spiracles; (C) caudal segment, 1—posterior spiracular plates, 2—compound sensillum.

formation from single aerial axillary buds also was reported for *P. kristinae* and *P. lisae* (Goeden and Teerink 1997).

Examination of 140 shoots on rhizome fragments excavated at study site 1 on 8.xii.1994, yielded seven shoots (5%) an average of 10.2 ± 0.6 (range, 1.9–23) mm in length that together bore 14 axillary buds and 16 ± 2.5 (range 7–25) early first instars per shoot. These infested axillary buds averaged 0.56 ± 0.06 (range, 0.37–1.12) mm in length by 0.42 ± 0.04 (range, 0.18–0.84) mm in width and each contained an average of 6 ± 1.0 (range, 1–16) early first instars (Fig. 6C). Infested buds were located an average of 3.9 ± 0.6 (range, 1.8–8.0) mm below the shoot apices (Fig. 6D).

Five infested shoots on five separate rhizome fragments excavated at the same site on 2.ii.1995 each bore an average of 14 ± 2 (range, 9–20) late first instars, or an average of 6 ± 1.4 (range, 3–10) larvae per axillary bud. The swollen axillary buds (incipient galls) measured 2.56 ± 0.67 (range, 0.74–4.56) mm long by 1.63 ± 0.35 (range, 0.74–2.56) mm wide and contained subspheroidal, open central cavities 0.2–0.4 mm in diameter (Fig. 6E). These incipient galls were borne on shoots that averaged 9.4 ± 1.4 (range, 6.6–13.7) mm in length (Fig. 6D).

The only galls found containing second instars were five in a sample collected at site 1 on 28.iii.1994. The subspheroidal galls contained an average of 4 ± 1 (range, 2–8) second instars and averaged 3.9 ± 1.4 (range, 1.5–9.1) mm in length by 5.9 ± 2.0 (range, 1.9–10) mm wide. Each gall contained a central cavity 1.1–4.0 mm in diameter and had walls 1.6 ± 0.2 (range, 1.3–2.6) mm thick (Fig. 6F).

Galls containing third instars, or sometimes third instars and puparia (Fig. 6H), were sampled more frequently than those containing the first two instars at both study sites. Twenty clusters of full-size galls as shown in Fig. 6G contained an average of 6 ± 1 (range, 1–14) galls and an average total of 12 ± 2 (range, 2–43) third instars per shoot. These galls were subspheroidal, ovoidal, or obclavoidal in shape and pale violet basally, whitish medially, and pale green or white apically (Fig. 6G). Forty-

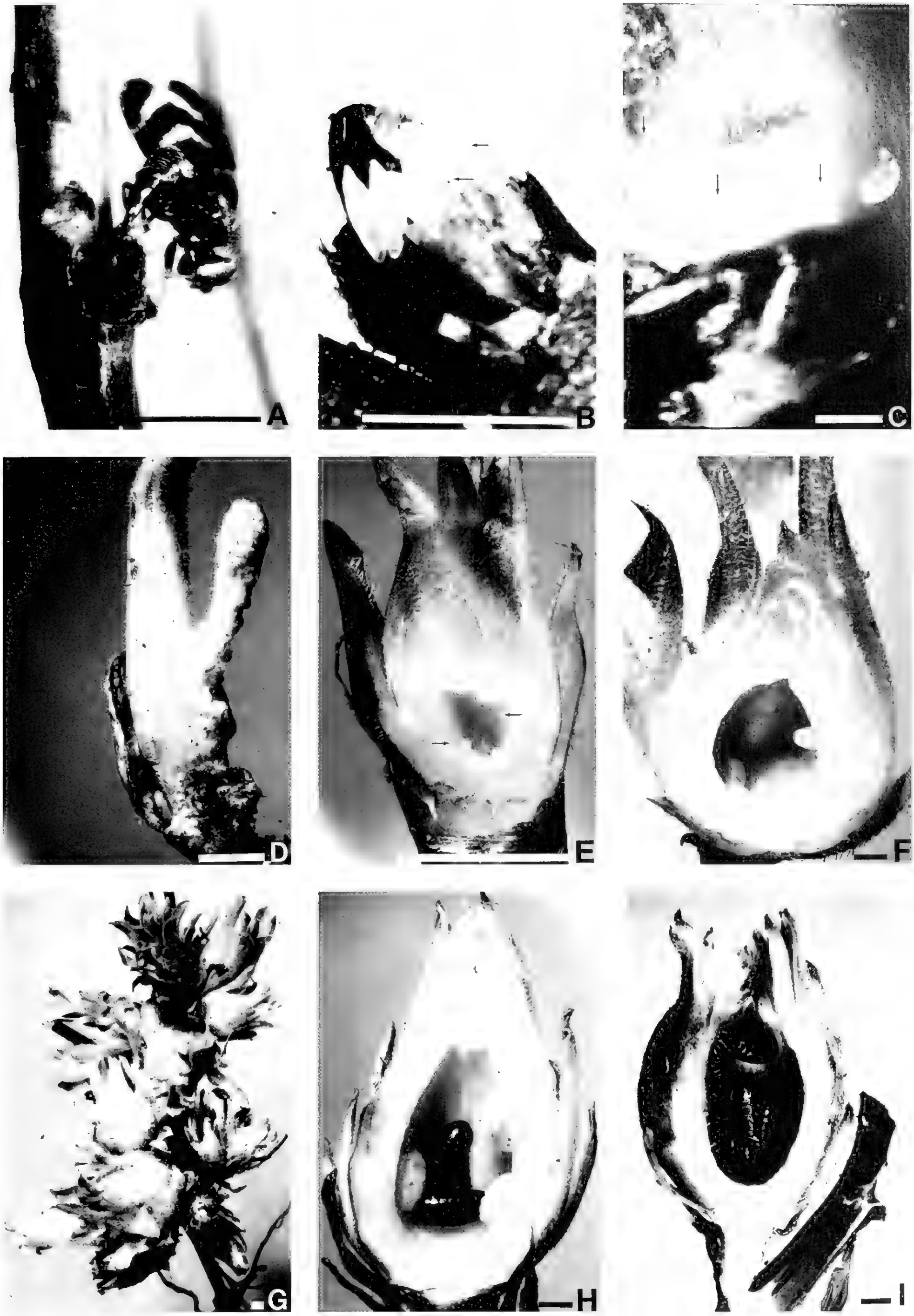

Fig. 6. Life stages of *Procecidochares anthracina* on *Solidago californica*. (A) ovipositing female, (B) axillary bud on shoot with bracts removed to show newly deposited eggs (arrows), (C) first instar larvae (arrows) feeding gregariously on shoot stem (line = 0.1 mm), (D) galled axillary bud on stalk of shoot dug from humus, (E) sagittal section of gall containing second instars (arrows), (F) sagittal section of gall containing early third instars, (G) cluster of full-size galls, (H) sagittal section through full-size gall containing third instars and puparia, and (I) full-size gall showing exit channel and empty puparia. Lines = 1 mm, except as noted.

four (54%) of 81 galls with third instars were borne on pedicels or stalks 7.7 ± 1.0 (range, 2–34) mm in length; the remainder (46%) were sessile on shoots. The 81 galls averaged 13.3 ± 0.3 (range, 8–20) mm in length and 8.0 ± 0.2 (range, 3.1–12) mm in width. Each gall contained an average of 3 ± 0.2 (range, 1–10) third instars within a subspheroidal, ovoidal, or obovoidal, open central cavity, which averaged 6.06 ± 0.20 (range, 1.84–10.64) mm in length and 3.81 ± 0.12 (range, 1.68–6.72) mm in width. Eighteen (22%) of these galls also bore an average of 2 ± 0.4 (range, 1–7) puparia indicating differential rates of development within galls. Another 145 galls were examined that only contained an average of 5 ± 0.4 (range, 1–21) empty (Fig. 6I) or still intact puparia.

Adult.—Eclosing adults emerge through a common, open exit channel at the apex of each gall, past and through an encircling whorl of bracts, and continue upward through the humus to reach the surface. Adults were relatively long lived among gallicolous congeners studied in southern California to date (Silverman and Goeden 1980, Green et al. 1993, Goeden and Teerink 1997). Twenty seven males lived an average of 47 ± 3 (range, 14–70) days in insectary cagings; 19 females averaged 38 ± 3 (range, 14–62) days. Females (Fig. 7A) are sexually immature at emergence (n = 3), but within a week produce a full complement of mature ova (n = 3), apparently mainly from tiny fat bodies (globules) observed in the haemolymph of newly emerged flies, which disappear during ovigenesis. In laboratory arenas, males 1–18 days old and females 1–22 days old mated (Fig. 7B, C), but this behavior, like oviposition, never was observed in nature nor were free-living adults ever collected.

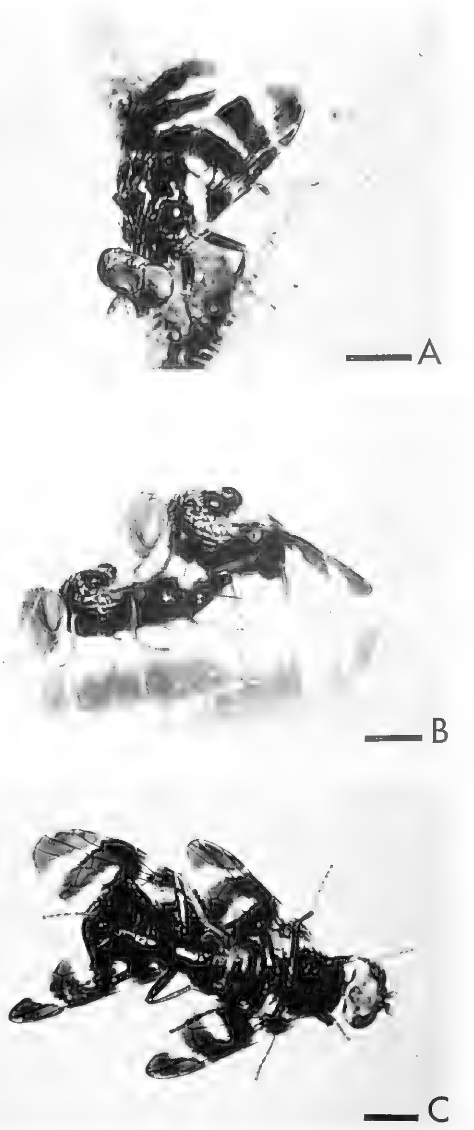

Fig. 7. *Procecidochares anthracina*. (A) dorsal view of female, (B) mating pair, lateral view, (C) Mating pair, ventral view. Lines = 1 mm.

The adults exhibited reproductive behavior typical of other circumnatal, gallicolous species of *Procecidochares* studied in southern California, i.e., a lack of courtship behavior, the exhibition of enantion type wing movements by both sexes, and male stalking of females prior to mating (Green et al. 1993, Headrick and Goeden 1994); however, they also displayed several unique behaviors in oviposition cages and petri dish arenas. For example, females displayed rapid enantion in brief spurts, two or three times per second after they alternately or synchronously supinated their wings through arcs of 20-30° as they briefly paused while walking along caged shoots between ovipositions, or while resting after ovipositing. So rapid was this enantion that the wings became blurred. Four females climbed atop prominent buds on excised shoots during oviposition in cages, recurved their abdomens, and inserted their aculei between bracts for an average of 6 ± 2 (range, 3–12) minutes, taking about 2 minutes to lay a single egg (Fig. 6A).

Both sexes displayed wing supination blending into rapid wing enantion while tracking each other in arenas prior to copulation, or rapid enantion during copulation if agitated, especially the females, just prior to and following postcopulatory separation. Twenty seven copulations averaged 63 ± 6 (range 25–148) minutes in duration and occurred throughout the day, but mostly at dusk. Males dismounted females either by walking forward over the head of the females or by stepping off to one side of her as she turned 180°, and they continued walking in opposite directions, as the male's genitalia was pulled free; the entire process lasted only a few seconds to as long as 20 seconds (n = 4). The only other unique behavior observed was between two different pairs of males which stood facing each other with their foretarsi overlapped and touched mouthparts or one male touched his labellum to the antennae and frons of the other male. Nonreceptive females resisted the attentions of males by head-butting; by turning swiftly towards males attempting to mount them from the rear, as is usual; and by not parting their wings and to prevent newly mounted males from grasping the females' anterolateral abdominal terga with their foretarsi.

Seasonal history.—*Procecidochares anthracina* is a univoltine, circumnatal species (Headrick and Goeden 1994) on *S. californica* in southern California. The overwintering stages are first- and second-instar larvae which continue their slow, protracted development beneath insulating snow and humus as the winter progresses. When spring arrives and their host plant resumes growth during April–May, the galls and larvae within resume their growth and development, the larvae pupariate, and the adults emerge in late summer (July–September), to mature, mate, and oviposit as described above.

Natural enemies.—Two species of chalcidoid Hymenoptera have been reared by us as parasitoids of *P. anthracina*. *Eurytoma obtusiventris* Gahan (Eurytomidae) is a solitary, larval-pupal endoparasitoid recovered from puparia that also has been reported from the tephritids, *Eurosta solidaginis* (Fitch) and *Neotephritis* (as *Tephritis*) *finalis* (Loew) (Bugbee 1967, Foote et al. 1993). *Pronotalia carlinarum* Gradwell (Eulophidae) is a gregarious puparial endoparastoid, the only species in this genus known from North America, and a known gregarious endoparasitoid of puparia, mainly Tephritidae, but also Agromyzidae and Chloropidae (LaSalle 1994).

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A REVISION OF THE NEOTROPICAL ANTS OF THE GENUS *CAMPONOTUS*, SUBGENUS *MYRMOSTENUS* (HYMENOPTERA: FORMICIDAE)

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Abstract.—The subgenus *Myrmostenus* consists of a group of 6 species of South American (Peru, Bolivia and Brasil) ants which are known only from the females. The species include ***C. convexiclypeus* MacKay (new species)**, *C. leptocephalus* Emery, *C. longipilis* Emery, *C. mirabilis* Emery, *C. postangulatus* Emery (**new status**) and *C. sphenocephalus* Emery. They are easily recognized as the head is greatly elongated and somewhat flattened. Nothing is known of the biology of this interesting subgenus. A key is provided for identification of the species.

Resumen.—El subgénero *Myrmostenus* consiste de un grupo de seis especies de hormigas de Perú y Brasil conocidas solamente por las hembras. Las especies incluyen ***C. convexiclypeus* MacKay**, *C. longipilis* Emery, *C. leptocephalus* Emery, *C. mirabilis* Emery, *C. postangulatus* Emery y *C. spenocephalus* Emery. Se pueden reconocer porque la cabeza es elongada y aplanada. La biología de estas hormigas interesantes es desconocida. Se incluye una clave para la determinación de las especies.

Key Words: Neotropics, Peru, Brasil, *Camponotus*, *Myrmostenus*, Areas neotropicales, Perú, Brasil

With the exception of the small Nearctic and European faunas, the genus *Camponotus* currently consists of poorly defined groups ("subgenera") in which species identification is nearly impossible. The genus as a whole is often considered an enormous group of rather bland ants, with few good characters for separating species. While this is probably true for some subgenera (i.e., *Tanaemyrmex*, *Mymobrachys*), there are certainly many exceptions. One of the most fascinating groups in the genus is the subgenus *Myrmostenus* which, unfortunately, is known only from the females. Species in this subgenus are easily recognized by their distinctive, elongate heads and, as this study reveals, have good characters for the separation of species. Nothing is known of the biology of this curious South American subgenus.

This is the first in a series of contributions towards the understanding of the New World species of this large, complex genus.

MATERIALS AND METHODS

Specimens were borrowed from several institutions and curators as follows:

AMNH, American Museum of Natural History, New York, Mark Smethurst.

CASC, California Academy of Sciences,

San Francisco, Darrell Ubick, Wojciech Pulawski.

LACM, Los Angeles County Museum, Los Angeles, Roy Snelling.

MCSN, Museo Civico di Storia Naturale, Valter Raineri (Emery Collection), Genoa, Italy.

MCZC, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, Stefan Cover.

USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C., David Smith.

Specimens were measured using an ocular micrometer in a dissecting microscope. The following abbreviations are used (all measurements in mm.):

HL, Head length, anterior of median lobe of clypeus to mid point of occiput (excluding occipital corners).

HW, Head width, maximum excluding eyes (immediately anterior to eyes).

EL, Eye length, maximum dimension.

SL, Scape length, excluding basal condyle.

Clypeal length, Distance from the tops of the lobes of the posterior border of the clypeus to the edge of the anterior medial border (Fig. 8a).

Clypeal width, Distance between the tentorial pits (Fig. 6b).

Clypeal index, Width/length × 100.

CI, Cephalic Index, HW/HL × 100.

SI, Scape index, SL/HL × 100 (note: HL used instead of HW).

SUBGENUS *MYRMOSTENUS*

Camponotus subgenus *Myrmamblys* (in part): Forel, 1914:271, 272

Camponotus subgenus *Myrmomalis* (in part): Forel, 1914:271

Camponotus subgenus *Myrmostenus* Emery, 1920:250, 260

Camponotus subgenus *Pseudocolobopsis* (in part): Emery, 1923:62

Type species of the subgenus *Myrmostenus*: *Camponotus mirabilis* Emery, 1903 (designated by Emery, 1920)

Diagnosis.—The females of this subgenus have greatly elongated heads with a CI ranging from 48–101. The pronotum is also long, together with the remainder of the mesosoma. The basal face of the propodeum is much shorter than the dorsal face. Most surfaces are smooth and shining. Erect hairs are usually sparse and decumbent pubescence is usually absent. The head has a few long, coarse hairs near the top of head and usually along the frontal carinae. The cheeks extend past the base of the mandibles, usually forming distinct lobes. The workers and males are unknown.

Description.—Female measurements (mm): HL 2.36–4.70, HW 1.44–2.52, SL 208–3.76, EL 0.56–0.98. Indices: SI 48–101, CI 40–67.

Mandible with 6 poorly defined teeth, except for apical and subapical; clypeus large and wide, often with well defined median carina; clypeal border slightly concave in all species except *C. mirabilis*; eyes large and extending past lateral edges of head; ocelli well developed; scape extending past posterior border of head (except in *C. mirabilis*); vertex concave or convex; maxillary palps with 6 segments; labial palps with 4 segments; mesosoma somewhat elongated and flattened; pronotum especially elongate; propodeum with long basal face and very short posterior face; petiole small, petiolar node relatively sharp.

Hairs sparse and coarse (except for *C. leptocephalus*, which has abundant erect hairs); decumbent pubescence essentially absent (except *C. leptocephalus*, which has sparse pubescence).

Sculpture fine, most surfaces smooth and polished, except head, which is punctate in most species.

Color medium brown.

Worker and Male: Unknown

Distribution.—Peru, Bolivia and Brasil.

Discussion.—These ants are considerably modified, possibly for living under bark or in tunnels in wood. It is difficult to determine the affinities with other subgenera in *Camponotus*, but the lobes associated with the cheeks, the enlarged clypeus and polished integument suggests that they may be related to *Pseudocolobopsis.* They are, however, much larger than any known *Pseudocolobopsis* females.

Biology.—Unknown.

Species Complexes

This subgenus contains three species complexes, the *leptocephalus* complex, the *longipilis* complex and the *mirabilis* complex. The *leptocephalus* complex consists of a single species, *C. leptocephalus.* This complex can be characterized as having a relatively larger CI (61), and having most surfaces covered with short, bristly hairs. The sculpture is rougher than in other species in the subgenus, especially obvious on the mesosoma. The *longipilis* species complex consists of four species: *C. convexiclypeus, C. longipilis, C. postangulatus* and *C. sphenocephalus.* These species can be characterized by having intermediate values of CI (51–67), lacking bristly hairs and having smooth and polished sculpture on the mesosoma and gaster, with the head sculptured to varying degrees with punctures. Finally, the *mirabilis* complex consists of a single species, *C. mirabilis.* This complex is characterized by having a very long head (CI 40–44), which is noticeably widened anteriorly, lacking short, bristly hairs and in being smooth and shining throughout, including the head.

I am not interested in defending the concept of subgenera as valid taxonomic groupings, but only as a groupings of convenience. In this instance, we can group three apparently related species complexes conveniently into a larger group, the subgenus *Myrmostenus.*

Key to the Females of the Ants of the Subgenus *Myrmostenus*

1\. Ventral surface of head with more than 5 erect hairs (Figs. 1, 2); occipital corners of head rounded (Figs. 4, 7, 8) 2
– Ventral surface of head without erect hairs, or rarely with 1 or 2 present; occipital corners of head angulate (Figs. 5, 6) 5

2(1). Surface of clypeus with more than 20 erect hairs (Fig. 8) . . . . *leptocephalus* Emery
– Surface of clypeus usually without any erect hairs (Fig. 7), although there may be occasional erect hairs along the borders (Fig. 5) 3

3(2). Head strongly narrowed posteriorly, the minimum posterior width less than the distance between eyes (Fig. 7) . . . . *sphenocephalus* Emery
– Head not strongly narrowed posteriorly (Figs. 4, 8), or minimum posterior width much greater than distance between eyes, nearly as wide as width of head anterior to eyes (Fig. 6) 4

4(3). Head relatively wide, CI > 60 (Fig. 4); scape long, SI > 85; eye large, maximum diameter > 0.85mm . . . . *convexiclypeus*, n.sp.
– Head narrowed, CI < 60 (Fig. 6); scape shorter, SI < 85; eye diameter smaller, maximum diameter < 0.85mm . . *longipilis* Emery

5(1). Head greatly elongate (CI 40–44) with strongly formed occipital angles (Fig. 5); relatively commonly collected . . *mirabilis* Emery
– Head not greatly elongate (CI 55), occipital angles poorly formed (Fig. 6); rarely collected . . . .*postangulatus* Emery

Clave para la Determinacion de las Hembras del Subgenero *Myrmostenus*

1\. Superficie ventral de la cabeza con 5 o más pelos rectos (Figs. 1, 2); esquinas occipitales de la cabeza redondas (Figs. 4, 7, 8) 2
– Superficie ventral de la cabeza sin pelos rectos; esquinas occipitales anguladas (Figs. 5, 6) 5

2(1). Superficie del clípeo con 20 o más pelos rectos (Fig. 8) . . . . *leptocephalus* Emery
– Superficie del clípeo usualmente sin pelos rectos (Fig. 7), aunque podría tener pelos rectos al margen (Fig. 5) 3

3(2). Cabeza muy angosta atrás, la anchura posterior menos que la distancia entre los ojos (Fig. 7) . . . . *sphenocephalus* Emery
– Cabeza no muy angosta atrás (Figs. 4, 8), o la anchura posterior casi tan ancha como la anchura inmediamente detrás de los ojos (Fig. 6) . . . . *longipilis* Emery

4(3). Cabeza no muy angosta (índice cefálico > 60, Fig. 4); escapo largo (índice del escapo > 85); diámetro máximo del ojo > 0.85mm . . . . *convexiceps*, n.sp.
– Cabeza angosta (índice cefálico < 60, Fig. 6); escapo más corto (índice del escapo < 85); diámetro máximo del ojo < 0.85mm . . . . *longipilis* Emery

5(1). Cabeza muy elongada (CI 40–44), con ángulos bien formados en las esquinas occipitales (Fig. 5); relativemente común . . . . *mirabilis* Emery

– Cabeza no demasiada elongada (CI 55), con ángulos poco diferenciados en las esquinas occipitales (Fig. 6); no comunes . . . . *postangulatus* Emery

DESCRIPTIONS OF SPECIES

***Camponotus* (*Myrmostenus*) *convexiclypeus* MacKay, new species**

(Figs. 3, 4; Map 2)

Diagnosis.—This is a large species with a head much wider than in the other species in the subgenus (2.52 mm vs. 1.44–2.00 mm in all other species in the subgenus). The clypeus is strongly convex as seen from above (Fig. 3). It has the usual coarse hairs on the vertex and also on the underside of the head.

Description.—Female measurements (mm): HL 3.76, HW 2.52, SL 3.76, EL 0.98, clypeus length 1.52, clypeus width 1.22. Indices: SI 100, CI 67, clypeal index 80.

Mandible with 6 teeth and an angle at basal margin; clypeus longer than wide, strongly convex (Fig. 3); anterior clypeal border concave with two lateral lobes; scape extending about ½ length past posterior border of head; head flattened in profile; vertex convex; maxillary palps short, about ¼ length of distance to foramen magnum; labial palps also short, about ⅓ length of maxillary palps; mesosoma lengthened as in other species; propodeum with poorly defined angle between two faces, posterior face appearing much shorter than basal face; petiole thin, with convex anterior face and straight posterior face (Fig. 2).

Hairs sparse, but coarse, some bent at angles and long (0.70–0.90 mm), area from vertex to upper edge of frontal carinae with about 20 coarse hairs, clypeus without hairs except for fringe at anterior border, about 20 hairs on underside of head, scapes with scattered erect hairs, up to 0.25 mm in length, dorsum of mesosoma with about 20 hairs, propodeum at point where faces meet with 6 hairs on left side, three on right side, node of petiole with three hairs on left, one on right, gaster with scattered hairs at the edges of each tergum but also on the other surfaces; decumbent pubescence almost absent.

Sculpture coarse on head, consisting of dense punctures, similar to that of *C. sphenocephalus*, remainder of body smooth and shining.

Color medium brown, head, including mandibles, scapes and funiculi, darker brown.

Type series.—Holotype ♀, PERU, Monson Valley, Tingo Maria, 11-xii-1954; E. I. Schlinger & E. S. Ross collectors.

Material examined.—Holotype ♀ (CASC).

Distribution.—Known only from type locality.

Etymology.—Refers to the strongly convex clypeus.

Discussion.—This species appears to be related to *C. sphenocephalus*, as the vertex is rounded and the head is densely punctate as in *C. sphenocephalus*. The head is wider as seen in full face view, thus making it easily separated from *C. sphenocephalus*.

Biology.—Unknown.

Camponotus (*Myrmostenus*) *leptocephalus* Emery

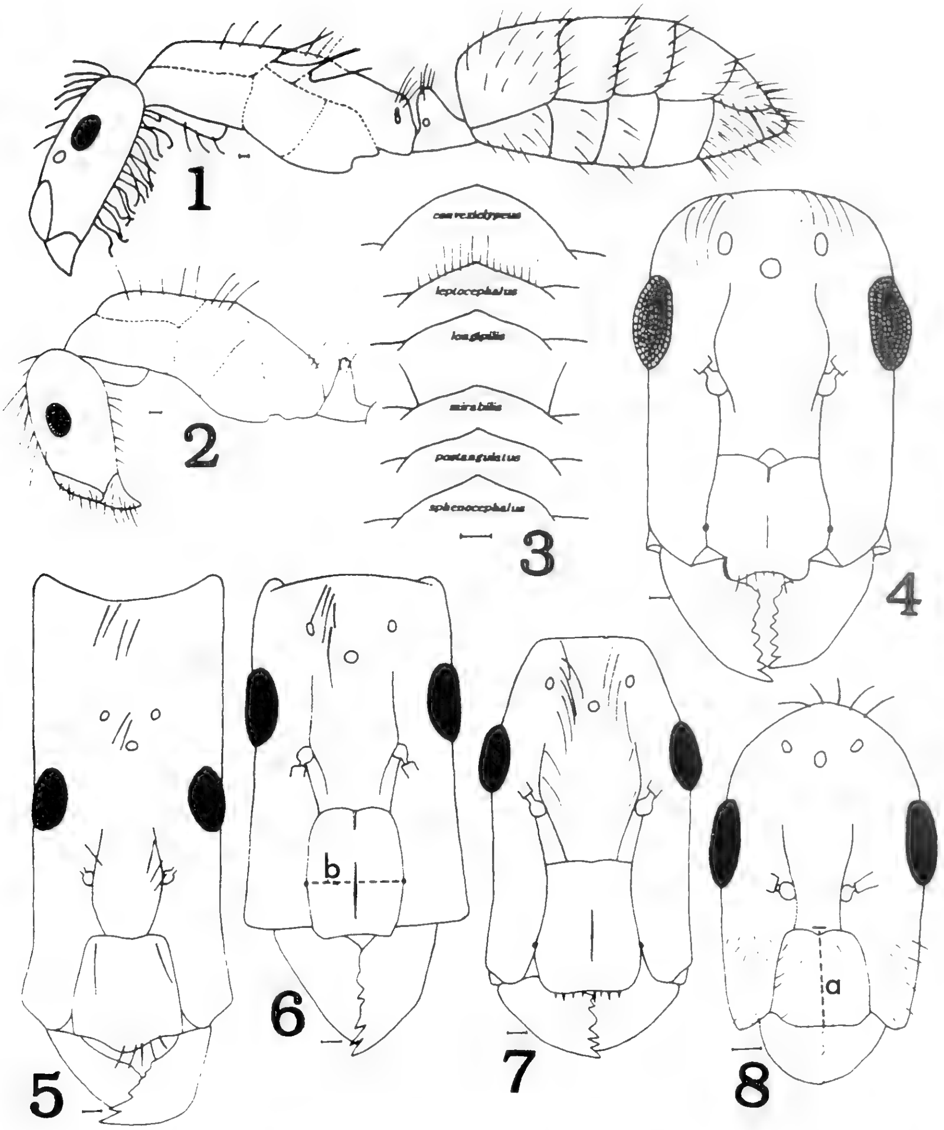
(Figs. 2, 3, 8; Map 1)

Camponotus (*Pseudocolobopsis*) *leptocephalus* Emery, 1923:62, female, Fig. 3, BRASIL, Espírito Santo, MCSN [seen].

Diagnosis.—This species has the least elongate head among the species in this subgenus (CI 61). It can be easily distinguished as it is much more hairy, with the hairs being primarily short bristles. The sculpture is relatively more rough than in the other species in the complex.

Description.—Female measurements (mm): HL 2.36, HW 1.44, SL 2.38, EL 0.56, clypeal length 0.74, width 0.70. Indices: SI 101, CI 61, clypeal index 95.

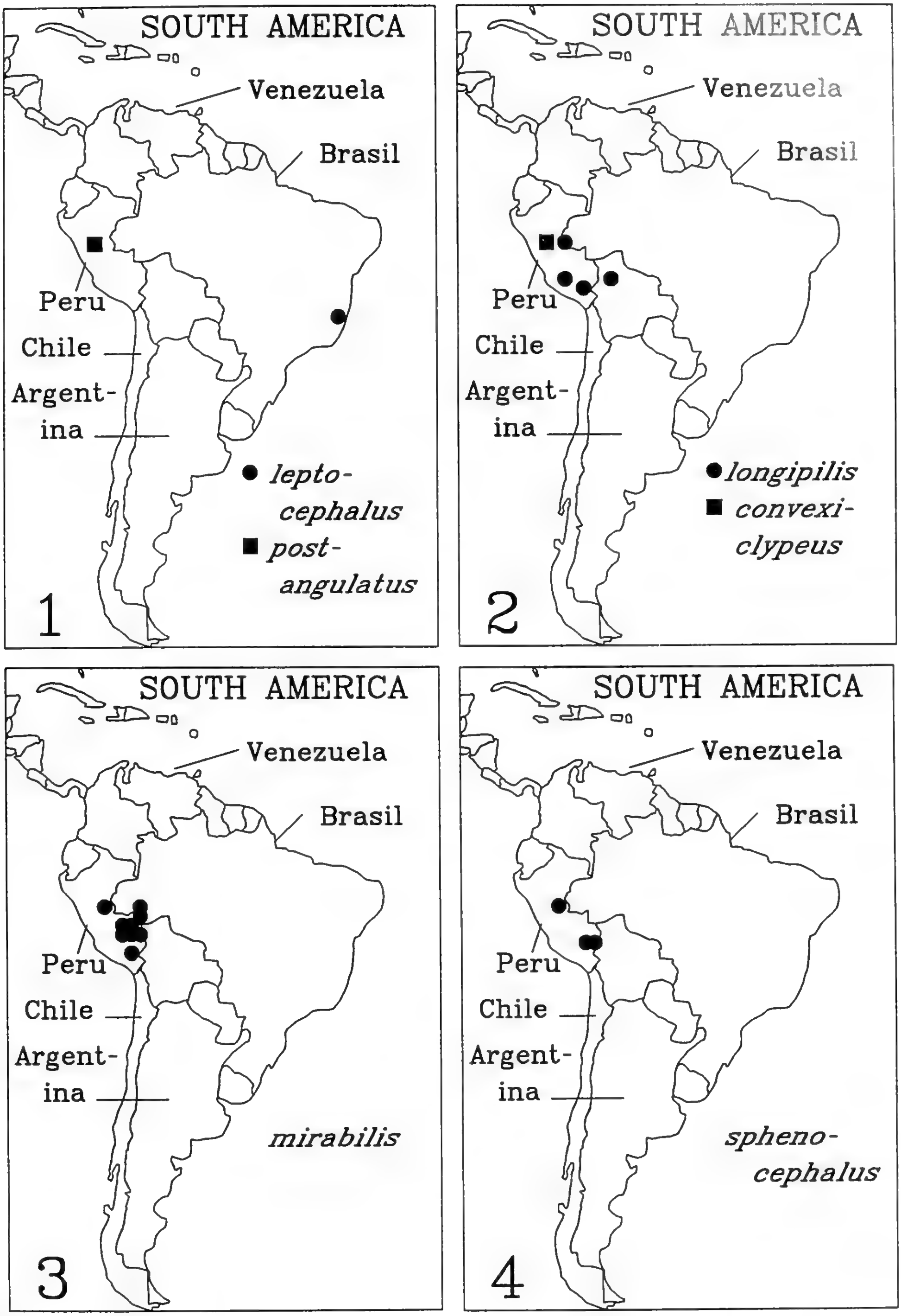
Mandible with 6 teeth; clypeus slightly longer than broad, with poorly defined median carina, anterior clypeal border slightly concave; scape long, extending nearly half



Figs. 1–8. Females of *Camponotus* (*Myrmostenus*); scales are 0.2 mm. 1, *C.* (*M.*) *longipilis*, lectotype from the side. 2, *C.* (*M.*) *leptocephalus*, lectotype head, mesosoma, and petiole. 3, Clypeus of the 6 species, as seen from the top. 4, Head of *C.* (*M.*) *convexiclypeus*, holotype. 5, *C.* (*M.*) *mirabilis*, head of lectotype. 6, *C.* (*M.*) *postangulatus*, holotype head (b indicates clypeal width measurement). 7, *C.* (*M.*) *spenocephalus*, holotype head. 8, *C.* (*M.*) *leptocephalus*, lectotype head (a indicates clypeal length measurement).

Figs. 1–8. Hembras de *Camponotus* (*Myrmostenus*); las escalas son de 0.2 mm. 1, *C.* (*M.*) *longipilis* lectotipo desde el lado. 2, *C.* (*M.*) *leptocephalus* cabeza, mesosoma y pecíolo del lectotipo. 3, Clypeus de las 6 especies. 4, Cabeza de *C.* (*M.*) *convexiclypeus* holotipo. 5, *C.* (*M.*) *mirabilis* cabeza del lectotipo. 6, *C.* (*M.*) *postangulatus* cabeza del holotipo. 7, *C.* (*M.*) *spenocephalus* cabeza del holotipo. 8, *C.* (*M.*) *leptocephalus* cabeza del lectotipo.

its length past posterior border of head; head slightly flattened when seen in profile; vertex concave when seen from the front and above, convex as seen in full face view; maxillary palps extending about ¾ distance to foramen magnum; labial palps about ⅓ length of maxillary palps; mesosoma lengthened as in other species; propodeum



Maps 1–4. Distribution of *Camponotus* (*Myrmostenus*). 1, *C.* (*M.*) *leptocephalus* and *C.* (*M.*) *postangulatus*. 2, *C.* (*M.*) *longipilis* and *C.* (*M.*) *convexiclypeus*. 3, *C.* (*M.*) *mirabilis*. 4, *C.* (*M.*) *spenocephalus*.

with posterior face about ½ of basal face; petiole with convex anterior face, nearly flat posterior face.

Hairs (erect and suberect) abundant on head and gaster, few scattered erect hairs on mesosoma and propodeum; decumbent pubescence scattered, but sparse on all body surfaces, length up to 0.06 mm in length.

Lightly but densely and evenly punctate on head, coriaceous on all surfaces of mesosoma and gaster.

Color concolorous medium brown, gaster slightly darker.

Type series.—Lectotype ♀ [here designated], Espir. Santo, X.1920-II.1921; Arp dedic; Camp. leptocephalus n. (MCSN) [seen]; second female not seen.

Material examined.—Lectotype ♀.

Distribution.—Known only from type locality.

Discussion.—This species forms one of the extremes in the range of head shape, sculpture and hairiness, and thus belongs to a separate species complex. The head is not as elongate as most of the other species (CI 61) or flattened as the other species. It appears to be distantly related to *C. sphenocephalus*, and can be easily separated as the clypeus is covered with erect hairs (none in *C. sphenocephalus*). This species is definitely not a member of the subgenus *Pseudocolobopsis*, as the maxillary palps are long, which is not found in species in *Pseudocolobopsis*.

Biology.—Unknown.

Camponotus (*Myrmostenus*) *longipilis* Emery
(Figs. 1, 3; Map 2)

Camponotus longipilis Emery, 1911:224, female, PERU, Huánuco: Pachitea (MCSN) [seen].

Camponotus (*Myrmamblys*) *longipilis*: Forel, 1914:271.

Camponotus (*Myrmostenus*) *longipilis*: Emery, 1920:260.

Diagnosis.—This species has an elongate head (CI 54–56) which is basically rectangularly shaped. It is identical to that of *C. postangulatus* (Fig. 6), except it lacks the occipital angles. The ventral surface of the head is covered with dense, long, erect, twisted hairs. The occipital corners are rounded and not angulate.

Description.—Female measurements (mm) : HL 3.44–3.58, HW 1.88–1.94, SL 2.68–2.88, EL 0.73–0.79, clypeal length 1.23–1.32, clypeal width 0.91–1.02. Indices: SI 78–84, CI 54–56, clypeal index 74–77.

Mandible with 6 teeth; clypeus longer than broad, widened anteriorly, surface strongly convex with well defined carina; clypeal border strongly concave; scape extending past posterior border of head; vertex weakly convex; maxillary palps short and delicate, extending about half distance to foramen magnum; labial palps also slender and about ½ length of maxillary palps; descending face of propodeum somewhat more than ½ length of basal face; petiole with strongly convex anterior face, straight posterior face.

Hairs erect, sparse, long and coarse on head (including underside of head), scattered on mesosoma and scattered on gaster; decumbent pubescence very fine and sparse on mesosoma and gaster.

Head weakly, but densely punctate, mesosoma and gaster coriaceous, but strongly shining.

Color medium brown, head, mandibles and scape darker brown.

Type series.—Lectotype ♀ (here designated), Pachita, Peru, Stdg; longipilis Emery (MCSN) [seen]; second female mentioned by Emery (1911) not seen.

Material examined.—23 ♀, including BOLIVIA: HuachiBení, ix-1921, W. Mann (1 ♀ USNM). PERU: Pachita, Marcapata, Staudinger (lectotype ♀ MCSN, CoType # 21592, MCZC, part of type series of *C. mirabilis*), Madre de Dios, Río Tambopata Reserve, 30 air km SW Pto. Maldonado, 290m, 6/25-xi-1979, J. B. Heppner (18 ♀ USNM), Cuzco, Pilcopata, 11/14-xii-1979, 600m, J. B. Heppner (2 ♀ USNM).

Distribution.—Peru and adjacent Bolivia.

Discussion.—This species would not be confused with any other in the *longipilis* complex, except *C. postangulatus*. It differs in that the occipital corners are not angulate and the ventral surface of the head is covered with long, coarse, erect hairs. The sculpture is similar to that of *C. leptocephalus*, but it lacks the abundant hairs on the dorsum of the head, having only a few scattered, coarse, erect hairs. The clypeal carina is also much more differentiated than it is in *C. leptocephalus*.

Biology.—Unknown.

Camponotus (*Myrmostenus*) *mirabilis* Emery
(Figs. 3, 5; Map 3)

Camponotus mirabilis Emery, 1903:80, Fig. 15, female, PERU, Vilcanota (MCSN) [seen].

Camponotus (*Myrmomalis*) *mirabilis*: Forel, 1914:271.

Camponotus (*Myrmostenus*) *mirabilis*: Emery, 1920:260.

Diagnosis.—This is the most common species in the subgenus, and is also easily differentiated from all others. The head is greatly elongated and noticeably widened anteriorly. The occipital corners are strongly angulate as seen in full face view. The clypeus is nearly flat, with little evidence of a raised region in the area of the clypeal carina. All of the surfaces, including the dorsum of the head, are strongly polished.

Description.—Female measurements (mm): HL 4.18–4.70, HW 1.82–1.88, SL 2.08–2.24, EL 0.66–0.70, clypeal length 1.19–1.28, clypeal width 0.98–1.08. Indices: SI 48–50, CI 40–44, clypeal index 82–84.

Mandible with apical and subapical teeth large, well defined, at least 4 additional teeth defined to various degrees; clypeus weakly convex with little evidence of clypeal carina as slightly raised strip; clypeal border convex and rounded; scape short and not reaching posterior border of head; head more than twice as long as wide, noticeably widened near mandibles; vertex strongly concave, with occipital corners strongly angulate; maxillary palps very short, barely extending past buccal region; labial palps nearly as long as maxillary palps; propodeum with descending face about half length of basal face; petiole with strongly convex anterior face, nearly flat posterior face, thicker and less in height than in the other species.

Hairs erect, long, coarse and sparse on dorsum of head, pronotum, scutum and scutellum, propodeum, node of petiole and gaster; decumbent pubescence very weak and sparse on most surfaces.

Sculpture weak, shiny and polished on most surfaces.

Color medium brown, head, mandibles and scape somewhat darker, gaster with yellow blotches on both sides of anterior section of terga.

Type series.—Lectotype ♀ [here designated], Vilcanota, Peru, Stdg; Camponotus mirabilis n. sp. (MCSN) [seen]; Marcapata, Peru; 2 paralectotypes [here designated], #21592 (MCZC 2 ♀, third female with same numbers and labels is *C. longipilis*).

Material examined.—105 ♀, including BOLIVIA: Río Bení, Rurrenbaque, W. Mann, Nov, 1921, Mulford Exped. (2 ♀ USNM). PERU: Maracapata (3 type ♀ MCSN, MCZC), Vilcanota and Marcapata; Loromayu, 400–500 m, ix-62, L. Pena (3 ♀ LACM, 1 ♀ MCZC), Cuzco Dept., Quincemil, 750m, 14/31-viii-62, Pena (2 ♀ MCZC), Pilcopata, 8/10-xii-1979, J. B. Heppner, (10 ♀ USNM), Madre de Dios, Cuzco Amazónico, 15K NE of Puerto Maldonado, S. Cover & J. Tobin, 23-vi-91 (1 ♀ MCZC), Madre de Dios, Avispas, 400m, 1/15-x-62, Pena (5 ♀ MCZC), Avispas, 10/30-ix-62, Pena (2 ♀ MCZC); in car Pucallpa X Aguaytia, 18-vii-1968, C. & B. O'Brian (1 ♀ CASC), Río Tambopata Reserve, 30 air KSW Puerto Maldonado, 12°50′S 69°20′W, 1/26-xi-1982, E. Ross (23 ♀ CASC), same locality, 1/4-v-1984, W. Pulawski (4 ♀ CASC), same locality, 290m, 2/30-xi-1979, J. B. Heppner, (48 ♀ USNM).

Distribution.—Southern Peru, Bolivia, and adjacent western Brasil.

Discussion.—This species is at the other extreme from *C. leptocephalus* in terms of its morphology. The head is startling in view, greatly elongated and slender. The ventral surface of the head lacks erect hairs. The entire surface is shiny. The occipital angles are well differentiated from the remainder of the head. This is one of the most fascinating ants from the Neotropical region, a true jewel in the genus *Camponotus*.

Biology.—Unknown. This species is relatively common. A rather minor effort in Peru would result in the collection of workers and males and reveal what would be expected to be an interesting story about this unusual species.

Camponotus (*Myrmostenus*) *postangulatus* Emery, **new status**
(Fig. 6; Map 1)

Camponotus longipilis var. *postangulata* Emery, 1911:225, female, PERU, Huánuco: Pachitea (MCSN) [seen].

Camponotus (*Myrmostenus*) *longipilis* var. *postangulatus*: Emery, 1925:161.

Diagnosis.—This species is very similar to *C. longipilis*, but can be separated easily as the occipital angles are well differentiated, and there are no erect hairs on the ventral surface of the head. The surface of the clypeus is strongly convex with a well differentiated clypeal carina.

Description.—Female measurements (mm): HL 3.62, HW 2.00, SL 2.84, EL 0.76, clypeal length 1.30, clypeal width 0.96. Indices: SI 78, CI 55, clypeal index 74.

Mandible with 6 poorly defined teeth; clypeus strongly convex with well developed carina; clypeal border weakly concave; scape extending past posterior border of head; head somewhat flattened when viewed in profile, shape identical to that of *C. longipilis*, except for presence of occipital angles; vertex concave, with well developed occipital angles; maxillary and labial palps as in *C. longipilis*; mesosoma and petiole as in *C. longipilis.*

Hairs; decumbent pubescence and sculpture as in *C. longipilis.*

Type series.—Holotype ♀, Pachitea, Peru, Stdg; longipilis var. postangulata Emery (MCSN) [seen].

Material examined.—Holotype ♀.

Distribution.—Central Peru.

Discussion.—This species is closely related to *C. longipilis*, but is distinct enough to be regarded as a valid species. In addition, the type locality for both species is the same. The characters in the key and in the diagnoses of the two species should be sufficient to separate the two species.

Biology.—Unknown.

Camponotus (*Myrmostenus*) *sphenocephalus* Emery
(Fig. 4; Map 4)

Camponotus sphenocephalus Emery, 1911: 225, female, PERU, Huánuco: Pachitea (MCSN) [seen].

Camponotus (*Myrmamblys*) *sphenocephalus*: Forel, 1914:272.

Camponotus (*Myrmostenus*) *sphenocephalus*: Emery, 1920:260.

Diagnosis.—This species has a strongly and densely punctate head, a strongly convex clypeus with well developed median carina, with numerous erect, coarse hairs on the underside of the head. The head is strongly narrowed posteriorly, with a rounded vertex. It is not closely related to any of the other known species, but is most similar to *C. longipilis* and *C. postangulatus*.

Description.—Female measurements (mm): HL 3.51–3.66, HW 1.78–1.96, SL 2.86–3.06, EL 0.78–0.81, clypeal length 1.34–1.36, clypeal width 0.93–0.95. Indices: SI 80–84, CI 51–54, clypeal index 68–70.

Mandible with 6 teeth; clypeus strongly convex with well defined carina; anterior clypeal border concave; scape extending past posterior border of head; head widened anteriorly and strongly narrowed posteriorly; vertex convex; maxillary and labial palps, mesosoma, petiole and gaster similar to that of *C. longipilis*.

Hairs erect, coarse and scattered on head, mesosoma, petiole and gaster; decumbent pubescence short and dilute on most surfaces.

Sculpture more coarse than other species, head strongly and densely punctuate, including surface of clypeus; mesosoma and gaster with much weaker sculpture than head, similar to other species except for *C. mirabilis*.

Color medium to dark brown, head, mandibles and scapes dark brown, gaster with slightly lighter splotches in same positions as in *C. mirabilis*.

Type series.—Holotype ♀, Pachitea, Peru, Stdg; sphenocephalus Emery (MCSN) [seen].

Material examined.—7 ♀, including PERU: Pachitea (1 ♀ MCSN); Madre de Dios, Cuzco Amazónico, 15 KNE Puerto Maldonado, S. Cover & J. Tobin, vi-1989 (1 ♀ MCZC), Río Tambopata Reserve, 30 air km SW Pto. Maldonado, 290m, 6/20-xi-1979, J. B. Heppner (5 ♀ USNM).

Distribution.—Peru.

Discussion.—This species can be easily separated from all others as the head, including the clypeus, is strongly sculptured. The head is strongly narrowed posteriorly, similar to that found in *C. leptocephalus*. It would not be confused with *C. leptocephalus*, which has abundant erect hairs on the top and bottom of the head, *C. sphenocephalus* has only a few, scattered hairs on these surfaces. This species is related to *C. longipilis*, but can be easily separated by the sculpture of the clypeus and the shape of the head.

Biology.—Unknown, collected in moist tropical forest at Río Tambopata Reserve.

ACKNOWLEDGMENTS

I thank the following curators and institutions for the loan of specimens: Mark Smethurst (AMNH), Darrell Ubick (CASC), Roy Snelling (LACM), Valter Raineri (MCSN), Stefan Cover (MCZC), David Smith (USNM). Emma MacKay, Stefan Cover and an anonymous reviewer provided a number of suggestions which improved the manuscript. A number of individuals collected the specimens, especially S. Cover, J. Heppner, W. Mann, L. Pena, W. Pulawski, E. Ross and J. Tobin. Without their selfless efforts, ant systematics would be in a worse state than it is.

This paper is dedicated to Dr. Valter Raineri, curator of the Emery collection, without whose help this revision and most of the other taxonomic work I have done with ants would not have been possible.

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PROC. ENTOMOL. SOC. WASH.
99(1), 1997, pp. 204

NOTE

Brachycerocoris camelus Costa (Hemiptera: Pentatomidae: Podopinae) in India: New Country Record

In a recent paper on the Asian species of *Brachycerocoris* Stål, the distribution of *B. camelus* Costa was given as Sri Lanka and China (Schaefer, O'Donnell, and Patton 1996, Oriental Insects 30: 203). I have now found in my own collection a specimen from Coimbatore, Madras State, India, which is 250–300 miles (about 50 of them water) from Sri Lanka. The specimen was collected October 16, 1953, and remains in my collection. It closely resembles the specimens of *B. camelus* described from China in Schaefer et al. (op. cit.), differing only in several features. The matted setae of the Chinese specimens are rubbed off on part of the abdominal sterna of the Indian specimen, revealing the deep reddish-brown of the cuticle itself. The following tubercles are broader, lower, and more rounded in the Indian than the Chinese specimens: medial tubercle on pronotum (Indian: tubercle length 11% of body length, height 67% of tubercle length; Chinese: 7% of body length, height equal to length), and the medial tubercle on the scutellum's posterior (Indian: tubercle length 13% of body length, height 43% of tubercle length; Chinese: 11% of body length, height 67% of length); the tubercle between the eyes is slightly more rounded in the Indian specimens than in the Chinese specimens.

This specimen represents a new country record, India.

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PROC. ENTOMOL. SOC. WASH.
99(1), 1997, pp. 205–207

BOOK REVIEW

Thrips Biology and Management. Edited by Bruce L. Parker, Margaret Skinner, and Trevor Lewis. NATO ASI Series A: Life Sciences Vol. 276. Plenum Press, New York, N.Y. 1995. 636 pp. $145.00 (cloth).

Thysanoptera, like other "minor" insect orders, have been essentially neglected by many entomologists in the past. Recently, however, interest in the group has suddenly begun to soar. This has been due at least in part to the ever-increasing sophistication of our agricultural and silvicultural systems and their heightened emphasis on thrips, mites, and other minute forms. Thysanoptera not only serve as vectors of phytopathogens, but their ever-increasing resistance to pesticides presents enormous management concerns. The most important thrips pests are confined to the family Thripidae and include *Frankliniella occidentalis* (Pergande) [Western flower thrips, WFT], *Thrips tabaci* Lindeman, and *Thrips palmi* Karny.

In recognition of the upsurge in worldwide interest concerning Thysanoptera, an international conference was held in Burlington, VT, U.S.A., in September, 1993, entitled: "Thysanoptera: Toward Understanding Thrips Management." The volume, *Thrips Biology and Management* resulted from this conference. The conference organizers included, besides the listed volume editors, Bruce S. Heming, Carl C. Childers, and Michael P. Parrella. The goals of the organizing committee in convening the conference as well as in production of the text included: pointing out critical research needs, obtaining fresh perspectives on various biological and pathogen vectoring parameters and on the complex management issues, and finally, providing important background information for decision-making in agricultural/silvicultural production, marketing, and quarantine systems. The conference hosted over 180 participants representing over 25 nations. The volume is a complete record of all oral (invited) presentations, and most of the graphic display presentations as well.

Following the Preface, the subject matter is divided into the following 9 Sections:

I. Introduction to Thrips/Plant Relationships
II. Pest Problems in Field, Forest and Glasshouse Crops
III. Vectoring of Plant Pathogens
IV. Biological Control Agents and Practices
V. Chemical Control
VI. Integrated Pest Management
VII. Biology and Behavior
VIII. Development and Genetics
IX. Field Sampling and Laboratory Techniques

Section One (4 papers) begins with extensive review articles by Laurence A. Mound and others concerning general thrips biology with emphasis on feeding behavior. It was stressed that the opportunistic feeding behaviors prevalent among Thysanoptera present a great potential for many previously non-economic species to become significant pests. The remainder of this section concerns the effects of thrips feeding and ovipositional activities on plant host tissues, and on whole plants.

Section Two (14 entries) begins with an excellent review by Thomas Leigh on the pest thrips of cotton on a worldwide basis. Following this is a series of articles on forest and orchard thrips pests in the U.S.A. and New Zealand, most involving the pear thrips, *Taeniothrips inconsequens* (Uzel). Other inclusions in this section involve thrips pests of vegetables and other crops around the world, ending with a paper by G. (Bert) Vierbergen on the international movement, detection, and quarantine of Thysanoptera pests.

Section Three (12 papers) consists mainly of articles concerning field and laboratory/electron microscopy studies of Tomato Spotted Wilt Virus (TSWV) and its thrips vectors, particularly *F. occidentalis*. Another virus vectored by *T. palmi* was reported from India. This section closes with two papers on thrips vectoring/assisting the spread of fungal phytopathogens. The Tospoviruses, including TSWV among others, are transmitted by at least 8 species of thrips to a wide variety of plant hosts, resulting in serious epidemics in many economic crops worldwide. Although in 1993, research on TSWV and its relationships with its thrips vectors at the tissue and cellular level was only in its initial phases, it was already being shown that thrips could indeed serve as primary vectors of the virus.

Section Four (21 entries) is primarily a compilation of preliminary/basic research reports on various aspects of thrips biological control. Many articles involved *Orius* (Heteroptera: Anthocoridae), and/or predatory mites (Phytoseidae: *Amblyseius*). Notable among these is one report from a Danish glasshouse nursery concerning their "Keep Down" approach. Inundative releases of *Orius* onto potted ornamentals when thrips were at initial low levels (BEFORE thrips reached pre-determined economic threshold levels), and maintaining thrips populations below economic levels resulted in high quality plants for the market. Additional entries in this section include a paper that discusses nematode parasitism of Thysanoptera, two papers on fungal pathogens of thrips (one, an extensive literature review) and finally, three articles emphasizing Thysanoptera as biological control agents for other economic pest groups, usually spider mites (Tetranychidae). Notable among the latter is a review article on the situation in cotton in the San juaquin Valley of California. Here, *F. occidentalis* has come to be considered a beneficial species which feeds on three species of spider mites. When mites are at high population levels, WFT serves as an important mite predator, but when mite populations are low, WFT then assumes importance as a prey species for a complex of generalist predators. These predators and WFT keep the mites under excessive levels at times when mites would otherwise become problematic. This has resulted in markedly reduced needs for chemical controls in San Juaquin Valley cotton.

Section Five (3 inclusions) titled "Chemical Control" was primarily concerned with resistance studies and the limitations of certain fumigation treatments. The first two articles concern resistance studies using diverse populations of WFT exposed to various pesticides. The last paper reports on a study of the fumigants naled and sulfotep, prospective replacements for methyl bromide, and the failure of either agent to achieve regulatory control of WFT in cut flower commodities (*Dianthus*).

Section Six (12 entries) contains 7 papers on WFT integrated/non-chemical management approaches, with the remaining papers in this section involving other species of thrips. As is true with the majority of the sections in this book, there is a mixture of review articles and basic/field research reports as well as other miscellaneous papers. There is an excellent "how-to" article which a nurseryman could use in designing an IPM program for greenhouse thrips management. Several papers are concerned with host plant resistance to WFT and other thrips; results with both flower crops and vegetables (cucumber) are promising.

Section Seven (11 papers) begins with an important article which summarizes over a decade of research in and around New York vegetable fields, concerning primarily *T. tabaci* and its relationships to cabbage. Another paper concerns the results of over 6 years of research in Georgia which elucidated population trends in the various thrips involved, and their inter-relationships with TSWV levels in peanut fields. Another important long-term study explores population trends in thrips of peach and nectarine orchards in Pennsylvania. A final long-term study concerns Thysanoptera species in meadows of the southern Carpathian mountains of Romania, and delineates relationships between species richness and altitude. Finally, two exquisite behavioral studies are included. One involves laboratory examination of chemical communication between WFT larvae and their predators, and the other examines detailed field behavior of natural male WFT aggregations in Utah.

Section Eight (3 submissions) most notably includes Gerald Moritz's evidence (using electron microscopy) that Thysanoptera are indeed Holometamorphic, and terminology for developmental stages in Thysanoptera should be egg, larva, pupa, adult.

Section Nine (11 entries) stresses methodology, and concerns survey techniques for field studies, as well as laboratory rearing/processing techniques.

In summary, *Thrips Biology and Management* is a volume that contains the work of thrips workers worldwide, and much of the included material involves basic research on *F. occidentalis.* It is well indexed, with: an index to thrips species/synonyms mentioned in the text; a list of conference participants; a thrips species index (those referred to in the text); and, finally, a subject index. Typographical errors were non-problematical other than the one on page 376, at the end of the first line of the last paragraph on the page: "in the early 1990's" should read "in the early 1900's."

Finally, persons who would find this book to be of interest and invaluable, include not only economic entomologists, but also general entomologists, federal and state policy makers, agricultural quarantine and extension personnel, commercial nurserymen (including those in greenhouse operations), farmers, crop scouting specialists, and anyone with a broad interest in various aspects of agriculture and forest pest management.

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PROC. ENTOMOL. SOC. WASH.
99(1), 1997, p. 208

OFFICIAL SEAL OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

The following history of the official seal appeared in the 1964 issue of the *Proceedings of the Entomological Society of Washington* (66(1): 1) and was written by Jon L. Herring, editor at that time.

The Official Seal of the Entomological Society of Washington

The story of the discovery of *Rheumatobates rileyi* Bergroth and its subsequent portrayal on the cover of our proceedings is an interesting one.

This small water strider was first mentioned in 1891 by Reverend J. L. Zabriskie (Jour. N. Y. Micro. Soc. 7: 128–129, 1 fig.) in an article entitled "A curious, unknown, aquatic, hemipterous larva." Then, in 1892, there appeared anonymously (Insect Life 4: 198) a complete description and excellent illustration of this bug, but it remained unnamed. On the basis of this description, Bergroth proposed the name *Rheumatobates rileyi,* new genus and species without further description (Insect Life 4:321). All of the above references dealt with apterous forms.

Otto Heidemann, specialist in Hemiptera, with the old Bureau of Entomology, collected the first winged specimens near Glen Echo, Maryland in 1893. Mr. Heidemann, who, in addition to his other talents, was a gifted engraver, made a handsome woodcut of a fully winged male. This figure appeared for the first time on the cover of volume 3, number 1 of our Proceedings (issued March 8, 1894).

The cut appeared continuously through 1920. It is mentioned in Mr. Heidemann's obituary in 1916 (Proc. Ent. Soc. Wash. 18: 202) that the illustration had been adopted as the official seal of our society. However, I am unable to verify this from the minutes of these early meetings.

The seal was dropped from the cover in 1921, presumably because the woodblock needed replacing. Later a photograph of the seal was made and a new illustration appeared on the June 1937 issue and has appeared continuously since then. Because much detail in the original has been lost, I have redrawn the seal, based on specimens from Glen Echo, and had a new cut made. The results can be seen on the cover of this issue.

The seal is widely recognized as a symbol of our society. As an example, one of the late Professor H. B. Hungerford's exam questions was, "Name the society whose official seal is *Rheumatobates rileyi*?"

Editor [Jon L. Herring]

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
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No. 17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00

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THE
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OF WASHINGTON

ORGANIZED MARCH 12, 1884

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MEETINGS.—Regular meetings of the Society are held in the Natural History Building, Smithsonian Institution, on the first Thursday of each month from October to June, inclusive, at 8 P.M. Minutes of meetings are published regularly in the *Proceedings.*

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REVISION OF THE *ERISTALIS* FLOWER FLIES (DIPTERA: SYRPHIDAE) OF THE AMERICAS SOUTH OF THE UNITED STATES

F. CHRISTIAN THOMPSON

Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, c/o National Museum of Natural History, MRC 168, Washington, DC 20560, U.S.A.

Abstract.—Three new species are described (***Eristalis alleni, E. gatesi,* and *Palpada eristaloides***); lectotypes are designated for *bogotensis* Macquart, *circe* Williston, *latifrons* Loew, *rufoscutata* Bigot, *stipator* Osten Sacken; new synonyms noted (*Eristalis tenuifrons* Curran 1930 = *Palpada semicircula* Walker 1852; *Eristalis aztecus* Hull 1935 = *circe* Williston 1891; *Eristalis colombica* Macquart 1855 = *tenax* Linnaeus 1758); and all species redescribed (*Eristalis bellardi* Jaennicke and *persa* Williston).

Key Words: key, neotropical

The Biodiversity Crisis is now the rage (NBS 1989; Wilson 1985a, 1988, 1992). Much has been written in both the scientific and popular literature. The world biota is disappearing at an alarming rate never before equaled in the history of this universe. That is not disputed. What we do not really know is what is being lost as our knowledge of our biota is abysmal. The big creatures, such as birds and mammals, as well as flowering plants, are known, named and classified, but the little ones, from the small, such as flies, worms and fungi, to the microscopic, such as protozoans, bacteria and viruses, are not well known, mostly unnamed and poorly classified (Erwin 1992; May 1990, 1992; Wilson 1987). To make them known will require the collaborative effort of many people, from collectors and taxonomists to computer scientists, statesmen and philanthropists (Raven and Wilson 1992; Roberts 1988; Yoon 1993). Costa Rica has started to build this collaboration. Their view of conservation is that biodiversity can only be conserved if people deem biodiversity to be of value. So, conservation is a process of saving it, then knowing it, so that it can be used sustainably (Janzen 1991). Costa Ricans have set aside a significant portion of their land to conserve wild biodiversity. They have established a national institute for biodiversity (INBio) to develop a cadre of professionals to inventory Costa Rican biodiversity and then to help others to find sustainable and profitable uses of this biotic wealth (Tangley 1990, Hovore 1991, Gamez and Gauld 1993). This inventory requires a universal naming system, which is provided by taxonomy (Thompson 1996). Taxonomy is global science, as many organisms are wide ranging and the groups that they are placed in are not necessarily defined by geography. Taxonomists, who tend to be clustered in the developed North (Gaston and May 1992), are themselves a dying breed (Wilson 1985b, Holden 1989, Culotta 1992, Novacek 1992). So, for taxonomists, the challenge is not only to name and classify our unknown biota before it is lost, but also to do it before they themselves are extinct! Or the alternative is to demonstrate more clearly their value. So, together some taxonomists have begun to work with Costa Ricans to inventory their biodiversity. This paper, which describes two new and spectacular flies known only from Costa Rica, is one result of this unique collaboration.

The pair of new species herewith described are most striking and beautiful species of *Eristalis* (Figs. 1, 2) that I know. Hence, I have named them after the brilliant pair of Paul Allen and Bill Gates, who have done more to bring power to the people through computer software. That in turn has allow for the blossoming of all of our talents, not the least the ability of systematists to more effectively and efficiently describe our disappearing biota.

Eristalis flower flies are common, sometimes abundant, in northern and montane temperate habitats. The adults are pollinators and the larvae, called rat-tailed maggots, are filter-feeders in organically rich waters, such as ponds, pools and ditches, aiding in nutrient recycling. Because of their diverse life-cycle, the species are good indicators of the health of their environments.

Eristalis was a broadly defined group when first established by Latreille (1804) and that definition was further enlarged by Fabricius (1805), whose interpretation was characterized as "ein mischmasch" by Meigen (1822: 382). Meigen restricted the name to those species with sinuate vein R4+5 and a petiolate cell R1 (although he didn't use these characters). Except for Zetterstedt (1837, 1838, 1842–60), who incorrectly used the name for *Cheilosia* of authors, all subsequent workers have followed Meigen's definition of *Eristalis*. Later, some authors, such as Rondani (1845, 1857) and Mik (1897), did subdive *Eristalis* into smaller components, but most authors continued to the use the name in the broad sense. The first and only modern attempt at subdivision of *Eristalis* was by Kanervo (1938), but his work was ignored. Vockeroth (in litt.) and Thompson (1972) re-examined Kanervo's work, and divided *Eristalis* into a few monophyletic groups. Most of the Neotropical species previously placed in *Eristalis* belong to *Palpada*; only a few belong to *Eristalis, sensu stricto*. A key to separate the Neotropical components of *Eristalis* of prior authors is appended. There has never been a revision of the Neotropical species of *Eristalis* (*sensu lato*). However, Curran (1930, 1934) did publish keys, which covered most of the species.

The *Eristalis* flower flies of Latin America present an interesting zoogeographic problem. Unfortunately, a character analysis of the genus *Eristalis* as whole has not been done, so a zoogeographic analysis of the Latin American species is speculative. What prior authors called *E. bogotensis* is a superspecies, consisting of *E. bellardii* in Mexico, *E. bogotensis* in northern and central South America and *E. croceimaculata* in southern South America. The *E. bogotensis* superspecies is characterized by a monomorphic abdominal pattern which consists of large reddish to orange lateral maculae, the extent of which varies clinally: *Eristalis bellardii* has the most extensive pale maculae, whereas *E. croceimaculata* has the least extensive pale maculae, and *E. bogotensis* is intermediate. This clinal variation in color has been noted in other flies and insects (see Zuska and Berg 1974) and is related to temperature. There is no component of the *E. bogotensis* superspecies in Central America. In Middle America, there are 4 species. In northern areas (Mexico (Chiapas) and El Salvador), there is a pair of sympatric sexually dimorphic species, *E. circe* and *E. persa,* in which the male has an orange abdomen and the female has a black abdomen. In the south (Costa Rica), there are two sympatric monomorphic species, one with an orange abdomen and the other with a black and yellow abdomen. The scenario these distributions and characters suggest is that there was a widespread ancestral species, which vicariated into 4 allopatric components, with the Middle American component undergoing further vicariance [Ancestral species = *E. bel-*

Figs. 1–2. Adult, dorsal view. 1, *Eristalis alleni*. 2, *E. gatesi*. ©Thompson 1993.

lardii + ((*E. circe* + *E. persa*) + (*E. gatesi* + *E. alleni*)) + *E. bogotensis* + *E. croceimaculata*]. The significance of such a scenario is that the higher elevations of Middle America have richer and more diverse faunas that those to the north or south, which is not unusual given the isolated nature of these areas (Fig. 3). Unfortunately, these ar-

Fig. 3. Middle America showing in black the areas of 2,000 meters or higher.

eas are limited in size and threatened by development.

KEY TO GENERA OF *ERISTALIS*-LIKE FLOWER FLIES FOUND IN THE NEW WORLD

1. Postalar pile tuft present; eye maculate; anepimeron with dorsomedial and posterior portions pilose; katepimeron bare; arista bare . . . . *Eristalinus*
– Postalar pile tuft absent; eye plain, without dark maculae; anepimeron with dorsomedial and posterior portions bare 2
2. Meron with pile anterior to and/or ventral of posterior spiracle; katepimeron pilose. Eye with uniform pile; wing microtrichose or bare . . . . *Palpada*
– Meron without pile near posterior spiracle; wing bare . . . . *Eristalis* 3
3. Katepimeron pilose; eye pilose, with 2 vertical vittae of darker, contrasting pile; arista pilose basally . . . . *Eristalis (s.s.)*
– Katepimeron bare; eye uniformly pilose, without darker vittae; arista bare or pilose . . . . *E. (Eoseristalis)*

KEY TO *ERISTALIS*-LIKE FLOWER FLIES OF AMERICAS SOUTH OF THE UNITED STATES

1. Katepimeron pilose 3
– Katepimeron bare 2
2. Meron without pile anterior to or ventrad of spiracle; arista with short but distinct pile on basal ½; eye densely pilose, with 2 vertical vittae of darker pile; wing bare . . . . *Eristalis tenax*
– Meron with pile anterior to and/or ventrad of spiracle; arista bare; eye pilose dorsally, without contrasting fascia of pile; wing microtrichose or bare . . . . *Palpada* species

3\. Arista bare 7

– Arista pilose at least on basal half 4

4\. Legs entirely black; pleura and femora black pilose; frons extensively yellowish-white pilose (Costa Rica) . . . . *Eristalis gatesi*

– Legs partially orange, at least on basal ⅓ of tibiae; pleura orange to yellowish pilose; femoral and frontal pile variable, usually femora partially yellow pilose and frons with at least some black pile 5

5\. Hind tarsus black; fore and mid tibiae with apical ¼ or more black; fore and mid tarsi brownish black apically; mesonotum including postalar callus and scutellum entirely orange to fulvous pilose; male abdomen orange with medial black maculae; female abdomen black (Mexico) . . . . *Eristalis circe*

– Hind tarsus, fore and mid tibiae, and tarsi orange; postalar callus at least partially black pilose; mesonotum and scutellum frequently partially black pilose 6

6\. Hind tibia almost entirely black, only with base and apex narrowly orange; face black; female abdomen entirely black; male abdomen orange to fulvous pilose; male fore femur with basoposterior tuft of long dense black pile (Mexico to El Salvador) . . . . *Eristalis persa*

– Hind tibia extensively orange, rarely with indistinct medial brownish annulus; face extensively tawny to orange in ground color; female abdomen reddish orange with medial black maculae; abdomen extensively black pilose; male fore femur without such a tuft of long pile (Costa Rica) . . . . *Eristalis alleni*

7\. Mesonotum with 3 transverse gray pollinose fasciae (Costa Rica, Panama) . . . . *Palpada semicircula*

– Mesonotum without pollinose fasciae 8

8\. Second tergum with a complete posterior black fascia (northern Mexico) . . . . *Eristalis stipator*

– Second tergum entirely reddish laterally, without a complete posterior black fascia, with black color restricted to medial area . . 9

9\. Antenna orange; hind tibia entirely orange; face orange (Ecuador) . . . . *Palpada eristaloides*

– Antenna dark, brown to black; hind tibia black on apical ½ or more; face black medially 10

10\. Coxae, katepisternum and metasternum yellow pilose; male with orange abdominal color extending laterally to apex of 4th tergum; front of female usually entirely pale pilose on ventral ⅔; male eye contiguity much longer than vertical triangle (2.5 to 1.5 times) (Mexico) . . . . *Eristalis bellardii*

– Coxae, metasternum and katepisternum ventrally partially to entirely black pilose; male with orange abdominal color extending only to base of 4th tergum; front of female partially black pilose on ventral ⅔; male eye contiguity shorter than vertical triangle (0.9 times) (South America) 11

11\. Female: 3rd tergum completely black; 2nd tergum with sides narrowly dark and posterior margin black on medial ⅔ or more. Male: 2nd tergum black on posteromedial ½ or more; 4th tergum completely black; male genitalia usually black pilose; aedeagus with ventral curved prongs narrow; superior lobe with only a short lateral carina (Chile, southern Argentina) . . . . *Eristalis croceimaculata*

– Female: 3rd tergum orange basolaterally; 2nd tergum with sides entirely orange, with posterior margin black only on medial ½ or less. Male: 2nd tergum with posterior margin black on medial ⅓ or less; 4th tergum frequently narrowly orange basolaterally; male genitalia yellow pilose; aedeagus with ventral prongs broad, flared; superior lobe with long carina extending from base to apex (Columbia, s. to Peru, Bolivia, & northern Argentina) . . . . *Eristalis bogotensis*

Genus *Eristalis* Latreille

Tubifera Meigen 1800: 34. Type species, *Musca tenax* Linnaeus (subsequent designation by Coquillett 1910: 618). Suppressed by ICZN 1963: 339.

Elophilus Meigen 1803: 274. Type species, *Musca tenax* Linnaeus (subsequent designation by Latreille 1810: 443). Suppressed by ICZN 1993: 256.

Eristalis Latreille 1804: 194. Type species, *Musca tenax* Linnaeus (subsequent designation by Curtis 1832: pl. 432).

Eristaloides Rondani 1845: 453. Type species, *Musca tenax* Linnaeus (subsequent designation of Coquillett 1910: 540).

Eristalomya Rondani 1857: 38. Type species, *Musca tenax* Linnaeus (original designation).

Eriops Lioy 1864: 743 (preocc. Klug 1808). Type species, *Musca tenax* Linnaeus (subsequent designation by Goffe 1946: 29).

Head: Face broadly pilose and pollinose laterally, usually shiny and bare medially, rarely entirely pollinose, straight except for medial tubercle and slight anterior production at antennal pits; tentorial pit short, extending along ventral third of eye; facial stripes indistinct; frontal prominence low, on dorsal third of head; eye pilose, holoptic in males; antenna short, about ¼ as long as face; basoflagellomere quadrate, slightly longer than broad.

Thorax: Slightly longer than broad, with long pile; anterior anepisternum bare; katepisternum continuously pilose from ventral to dorsal margin; anepimeron with dorsomedial and posterior portions bare; metathoracic pleuron bare; metathoracic spiracle, large, larger than basoflagellomere; plumula long and multibranched.

Legs: Simple, hind femur not swollen, hind tibia without basal nor apical carina nor apical dens. Wing: Bare; cell R1 closed and petiolate; cell R4+5 petiolate, with petiole as long as stigmatic crossvein; stigmatic crossvein present.

Abdomen: Oval to suboval.

Subgenus *Eristalis*

Eye with two denser vertical vittae of pile; arista bare; katepimeron pilose.

The subgenus *Eristalis* contains only 2 species, *E. proserpina* Wiedemann from China, and *E. tenax* Linnaeus, an Old World synanthropic species which is now cosmopolitan.

Eristalis (Eristalis) tenax (Linnaeus)
(Figs. 4, adult; 5, larva)

Musca tenax Linnaeus 1758: 591 Sweden (restricted Thompson et al. 1982: 160). LT ♂ LSL (designated Thompson et al. 1982: 160).

Eristalis tenax: Brèthes 1907: 293 (Argentina, catalog citation); Kertész 1910: 238 (catalog citation); Porter 1921: 447, 1924a: 82, 1924b: 98, 1927: 122, 1928: 224, 1932: 190, 1934: 170, 1938: 155 (Chile); Hull 1925: 305 (description); Curran 1930: 6, 1934: 410 (key references); Shannon & Aubertin 1933: 163 (Chile); Ruiz & Stuardo 1935: 318 (Chile); Gutierrez 1939: 35 (Chile); Enderlein 1940: 662 (Juan Fernandez Is.); Stuardo 1946: 128 (catalog citation, Chile); Fluke 1957: 144 (catalog citation, Chile, Argentina); Etcheverry & Shenefelt 1962: 208 (Male genitalia figured); Etcheverry 1963: 44 (synonymy, Chile); Thompson et al. 1976: 101 (catalog citation); Thompson 1972: 140 (Male genitalia figured), 1981: 146 (West Indies, status).

Eristalomyia tenax: Enderlein 1940: 662 (Juan Fernandez Islands).

Tubifera tenax: James 1947: 151 (habitus illustrated, description, myiasis, distr.).

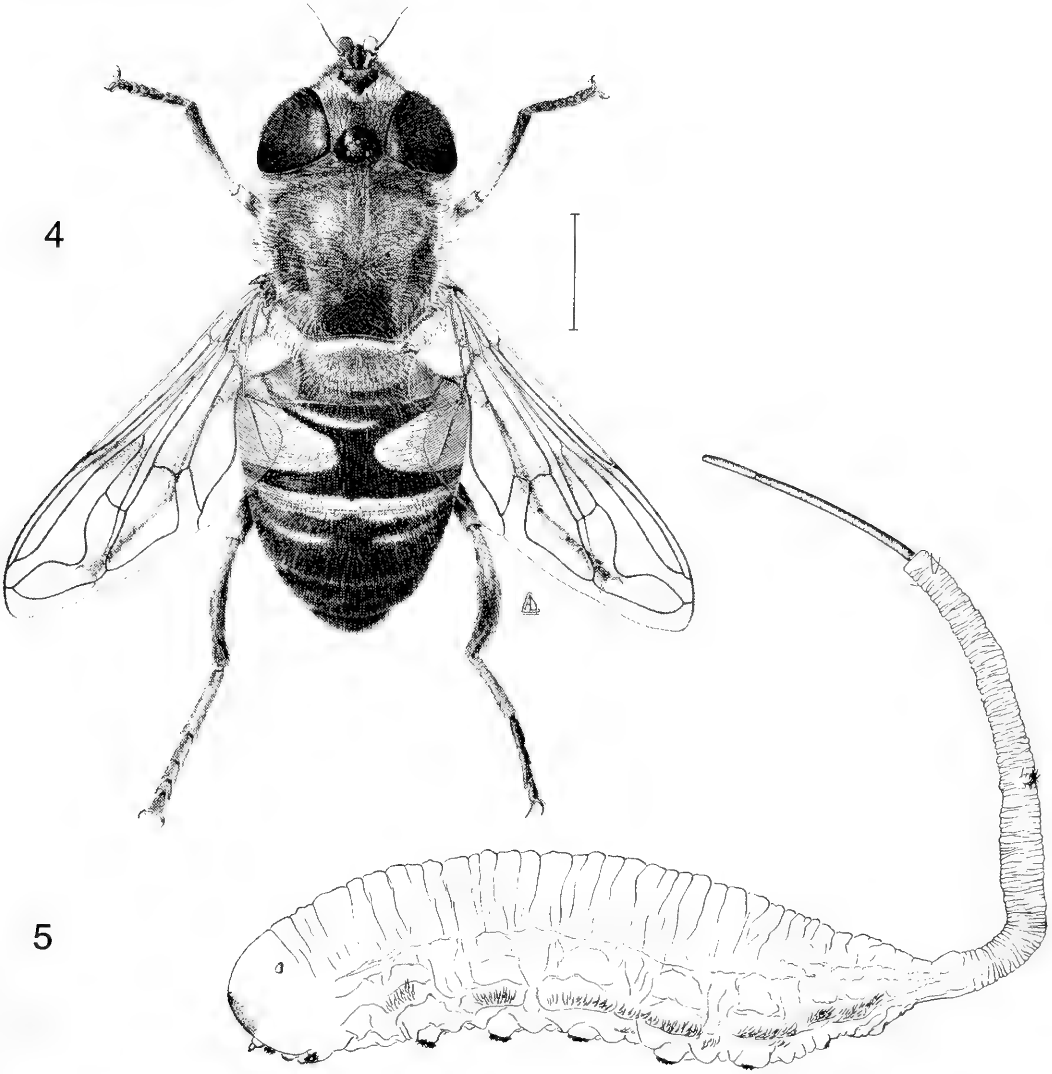
Eristalis columbica Macquart 1855: 108 ♀ Columbia. LT ♀ BMNH here designated. Williston 1886: 319 (catalog citation); Kertész 1910: 215 (catalog citation); Fluke 1957: 154 (catalog citation, sp. incerta sedis). **New synonym.**

Palpada columbica: Thompson et al. 1976: 104 (catalog citation)

Male.—Head: Black; face yellowish-gray pollinose except broad shiny medial vitta, yellow pilose; gena shiny, yellow pilose; frontal lunule brownish orange except black medially; frontal triangle shiny and black pilose apicomedially, yellowish-gray polllinose and yellow pilose laterally; vertical triangle dull black pollinose, black pilose; eyes holoptic, with eye contiquity short, about as long as ocellar triangle; occiput yellowish-gray pollinose, yellow pilose; antenna brownish black; arista bare, brown.

Thorax: Black, yellowish gray pollinose, yellow pilose, postalar callus yellow pilose; scutellum yellow, shiny, yellow pilose; squama and plumula orange yellow; spiracular fringes light brownish yellow; halter yellow, with brown head; wing hyaline, bare; epaulet yellow pilose; basicosta black and yellow pilose. Legs: Brownish black except orange femoral-tibial joints and mid basotarsomere on basal ¾, yellow pilose except hind femur black pilose apicoventrally on posterior edge, hind tibia black pilose posteriorly and hind tarsus black pilose.

Abdomen: Brownish yellow pilose; 1st



Figs. 4–5. *Eristalis tenax*. 4, Adult, dorsal view. 5, Larva, lateral view.

sternum gray pollinose, brownish black except paler laterally; 2nd sternum shiny, yellow except medial ⅓ brownish black; 3rd sternum shiny, black except paler basolaterally; 4th sternum shiny, black; 1st tergum gray pollilnose, black; 2nd tergum black except orange apical margin and large mediolateral ovoid orange macula, with macula occupying full lateral width and extending to medial ¼; 3rd tergum shiny, black except narrow orange apical, broader orange anterior margin except medial ¼, and broad orange mediolateral fascia, with fascia connected basolaterally to pale anterior margin, with fascia from ⅙ to ¼ tergal length; 4th tergum shiny, black, rarely narrowly orange basolaterally; genitalia shiny, black.

Female.—Similar; front shiny dorsad lunule and anterior to ocellar triangle, elsewhere yellowish gray pollinose, which is lighter ventrolaterally and darker dorsomedially, extensively black pilose, with yellow pile intermixed medially and ventrolaterally, about .4 times as wide as head at antenna, tapering to about .35 times as wide dorsally; frequently with abdominal orange maculae reduced, sometimes greatly so, in such specimens no pale macula on 3rd tergum and macula on 2nd tergum reduced so as to be broadly isolated from apical margin; 5th sternum gray pollinose, black; 5th tergum shiny, black.

Type data.—*Musca tenax* Linnaeus, lectotype ♀ Linnaean Collection, London, labelled "tenax 41" and "Lectotype, Musca tenax Linnaeus, Thompson et alia 1981."

Eristalis columbica Macquart, lectotype ♀ British Museum (Natural History), London, labelled "Holotype" [red circular type label], "ex. coll. Bigot, Pres. by, G. H. Verrall, B. M. 1894—234;" "Eristalis, colombicus, ♀ Macq." [in Macquart's hand] and "E. columbicus ♀, Columbia Macq." [Bigot determination label].

Neotropical material examined.—MEXICO. *Aguascalientes*: 1 Dec 1909, F. C. Bishopp (1 ♂ 1 ♀ USNM). *Baja California Norte*: Ensenada, 6 Sep 1958, P. H. Arnaud, jr. (1 ♀ USNM); Estero Beach, 9 km south of Ensenada, sea level, 5 Jul 1973, P. H. Arnaud, Jr., 5 Jul 1973 (1 ♂ USNM). *Chiapas*: San Cristobal las Casas, 7100 ft., 1–5 Aug 1966, D. E. Breedlove (1 ♂ USNM); "Las Casas," 27 Apr 1945, A. J. Sharp (1 ♀ USNM). *Federal District*: 7/8/10, F. C. Bishopp; Federal district: "7+8 10" (1 ♀ USNM); Coapa, 25 Aug 1970, E. G. Smyth (1 ♀ USNM); Mexico City, 17 Sep (1 ♀ USNM); same data, but Crawford (1 ♀ USNM). *México*: 20 May 1922, E. G. Smyth (1 ♂ 1 ♀ USNM); Atzcaap'co, 31 Aug 1922, E. G. Smyth (3 ♀ USNM); Teotihuacann, Pyramid to the sun, 27 Dec 1970, P. H. Arnaud (1 ♂ USNM). *Michoacán*: Morelia, Jun 1965, N. L. H. Krauss (1 ♀ USNM); Velez Sarssfield, 9 Sep 1926, M. R. Riesel (1 ♀ USNM). *Nuevo León*: Villa de Garcia, 25 May 1975, J. Abercrombie (1 ♀ USNM). *Veracruz*: 5 miles southwest of Perote, 29 Feb 1972, F. Parker & D. Miller (1 ♂ 1 ♀ USNM); 9 miles southwest of Toluca, 27 Nov 1965, M. W. McFadden (5 ♂ 3 ♀ USNM). GUATEMALA. *Guatemala*: Puerta Parada, 14.5 km east Guatemala City, 16 May 1979 (1 ♂ USNM). BRAZIL. *Paraná*: Curitiba, 27 Dec 1936, Westermann (1 ♀ USNM); *Santa Catarina,* Nova Teutonia, 27°11'S 52°23W, 300-500 m, F. Plaumann, 19 Feb 1940 (3 ♂ USNM), Apr 1947 (1 ♀ USNM); Nov 1971 (12 ♂ 12 ♀ USNM), Nov 1964 (2 ♂ 8 ♀ USNM). *Rio Grande do Sul*: Pelotas, C. M. Biezanko, 19 Jan 1956 (2 ♀ USNM), 29, 30 Sep 1961 (5 ♂ 4 ♀ USNM), 27, 29 Oct 1960 (2 ♂ 4 ♀ USNM), 31 Oct 1959 (1 ♂ 3 ♀ USNM), 5, 11 Nov 1956 (3 ♂ 4 ♀ USNM), 3, 7 Nov 1960 (8 ♂ 6 ♀ USNM). URUGUAY. Montevideo, J. Tremoleras (1 ♂ 1 ♀ USNM). ARGENTINA. *Buenos Aires*: Bahia Blanca, 29 Jan 1922, D. S. Bullock (2 ♂ USNM); Rio Santiago, Palo Blanco Berisso, 3 Dec 1979, C. M. & O. S. Flint; Baradero, Rio Parana de las Palmas Lima, 16 Dec 1979, C. M. & O. S. Flint (1 ♂ USNM); Balneario Municipal, Baradero, 15 Dec 1979 (1 ♀ USNM); Buenos Aires, Jun 1928, A. Copello (4 ♂ 2 ♀ USNM); La Plata, 20 Apr 1927, Kisluk (1 ♂ USNM); Zalaya, Nov 1939, J. B. Daguere (1 ♂ 2 ♀ USNM); Capital, Feb 1939, J. B. Daguerre (1 ♀ USNM); 7, 24 & 25 Feb 1962, W. L. Jellison (1 ♂ 3 ♀ USNM); Azul, 7 -25 Feb 1962, W. L. Jellison (1 ♂ 3 ♀ USNM); Villa Eliza, 15-29 Dec 1979 (1 ♂ MZUSP); Villa Eliza, Ao. Carnaval, 3 Dec 1979, C. M. & O. S. Flint (4 ♂ 1 ♀ USNM); *Catamarca*: Andalgala, 20 & 28 Oct 1972, J. L. Neff (2 ♂ 2 ♀ USNM); *Entre Rios*: Pronunciamiento, Apr & Dec 1966, F. Walz (3 ♂ 3 ♀ USNM); *Neuguen*: Rio Alumine, 9 km north Alumine, 27 Feb 1978, C. M. & O. S. Flint (1 ♀ USNM); Ao. Chapelco Chico E. S. M. d. l. Andes, 25 Feb 1978, C. M. & O. S. Flint (1 ♂ USNM). CHILE. Southern Chili, 25 Jan 1907, M. J. Rivera (5 ♂ 5 ♀ USNM). *Aconcagua*: ConCon, 16 Dec 1950, Ross & Michelbacher (1 ♂ USNM). *Antofagasta*: Nov 1932, A. Pirion (1 ♂ USNM). *Araucania*: Angol, D. S. Bullock (1 ♂ 3 ♀ USNM); 11, 23 Mar 1925 (4 ♂ 4 ♀ USNM), 15 Jun 1933 (1 ♀ USNM), 22 Nov

1951 (1 ♀ USNM). *Cautín*: Rio Cautin, Cajon, 3 Jan 1966, Flint & Cekalovic (1 ♀ USNM). *Concepción*: Concepcion, Dec 1926, R. & E. Shannon (1 ♂ 1 ♀ USNM); Hualpencillo, 31 Dec 1965, Flint & Cekalovic (1 ♂ USNM). *Llanguihue*: Puerto Varas, Dec 1926, R. & E. Shannon (1 ♀ USNM). *Maule*: Pellines, south of Constitucion, 16 Dec 1976, A. B. Gurney (1 ♀ USNM). *Osorno*: Anticura, 1 km west of, 430 m, 11–12 Feb 1978, W. N. Mathis (4 ♂ 1 ♀ USNM); Aguas Calientes, 1 km southest of, 530 m, 7–8 Feb 1978, W. N. Mathis (1 ♂ USNM); Pucatrihue, 27–30 Jan 1978, W. N. Mathis (1 ♀ USNM). *Santiago*: Santiago (1 ♂ USNM); El Portezuelo, 7 km north of Santiago, 500 m, 22–25 Oct 1981, D. & M. Davis (1 ♀ USNM); near Pta. Yeso, ca. 70 km southeast Santiago, 1250 m, 27-28 Oct 1981, D. & M. Davis (1 ♀ USNM); Santiago, "10.K.N.09" 29 Jan 1932, Kisliuk & Cooley (1 ♀ USNM), 29 Feb 1932, Kisliuk & Cooley (1 ♀ USNM); *Valdivia*: Rio Bueno, 8 miles east of, 15 Jan 1951, Ross & Michelbacher (1 ♂ USNM). *Valparaiso*: Valparaiso, A. Faz (1 ♂ 1 ♀ USNM), 5 Aug, Cockerell (1 ♂ USNM); Quillota, Quintolaurel, Kisliuk & Cooley (1 ♀ USNM).

Distribution.—Cosmopolitan. *Eristalis tenax* is rare in collections from the Neotropics. In temperate areas the species has spread everywhere humans have. In the Americas south of the United States, *Eristalis tenax* is amphitropical, ranging south to Guatemala and north to Southern Brazil.

Discussion.—*Eristalis tenax* is a mimic of the honey bee (*Apis mellifera* L.). Much has been written on the species as it has been used as an experimental subject in various laboratory studies, a pollinator in greenhouse, and the basis of the Bugonia myths.

Subgenus *Eoseristalis* Kanervo

Eoseristalis Kanervo, 1938: 12. Type species, *Eristalis cerealis* Fabricius (Orig. des.).

Eye without contrasting pile fasciae; arista usually sparsely pilose basally; meron bare.

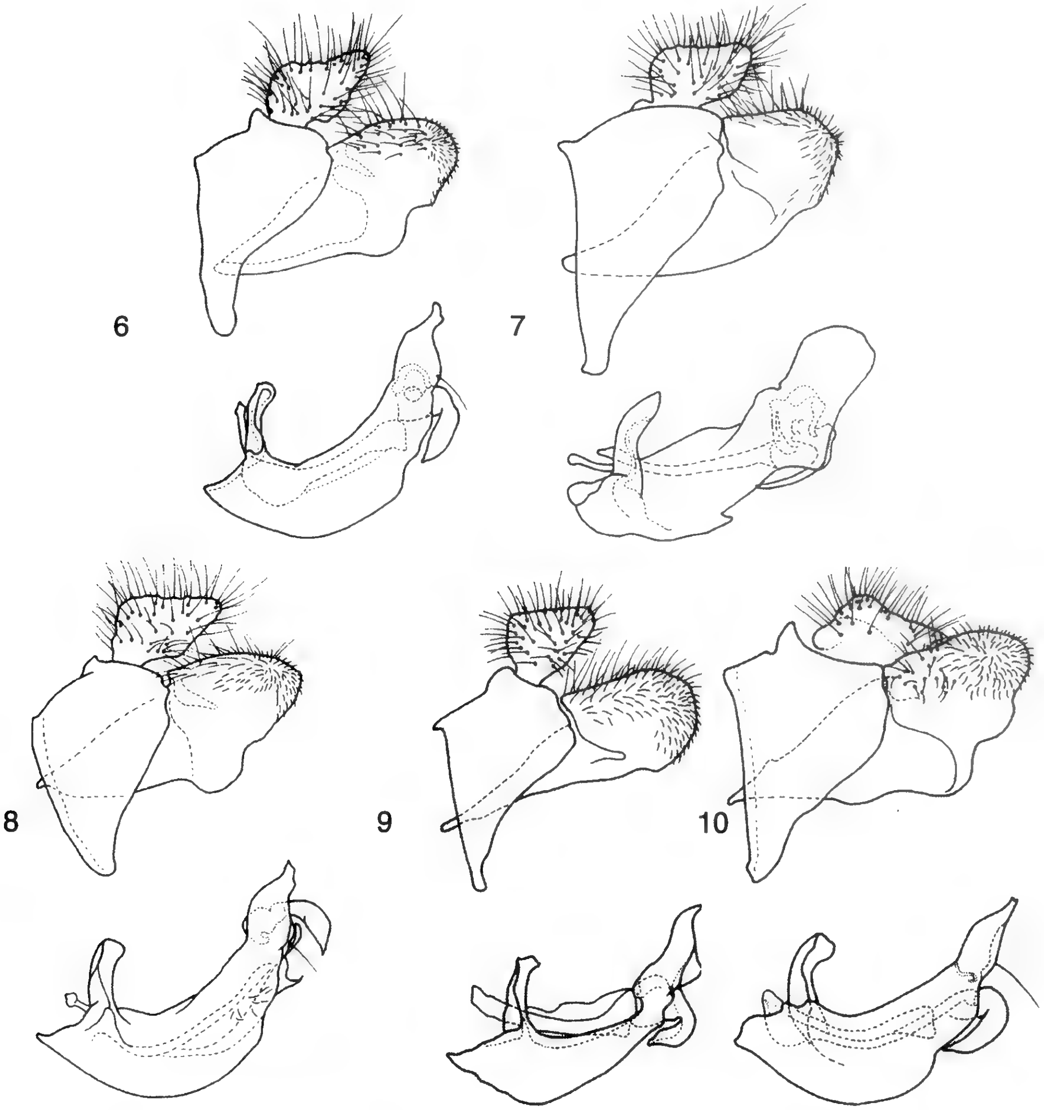
The subgenus *Eoseristalis* includes some 60 species, mainly distributed in the north temperate regions (39 Palaearctic species, 20 Nearctic species), with fewer species in the cooler areas of the Afrotropics (4 species), Orient (11 species) and the Neotropics (5 species).

***Eristalis (Eoseristalis) alleni* Thompson, new species**

(Fig. 1, habitus; 8, male genitalia)

Male.—Head: Black; face brownish orange except for black oral margin and a narrow medial black vitta which extends vertically above tubercle, brownish orange pilose, dull grayish white pollinose, with pollinosity thin, not obscuring ground color; gena grayish white pollinose; frontal and vertical triangle brownish orange pollinose, black pilose; eye brown pilose on dorsal ½, yellow on ventral ½; occiput silvery white pollinose, yellow pilose, with some black pile on dorsal ⅓; antenna orange except darker brown on dorsoapical ⅔ of basoflagellomere; arista orange, distinctly pilose, with pile about ½ as long as basoflagellomere width; eye contiguity short, about as long as ocellar triangle.

Thorax: Black, grayish brown pollinose; scutum with very indistinct pattern of darker pollinose narrow submedial and broader interrupted sublateral vittae, extensively black pilose, with orange pilose marginally (anteriorly, laterally and posteriorly); scutellum dark orange, dull, black pilose except apical margin yellow pilose; pleuron orange pilose except black pile dorsoposteriorly on anepisternum and posteriomedially on katepimeron; metasternum black pilose. Legs: Orange except black coxae, trochanters and basally on femora; orange pilose except black pilose on mid and hind coxa, dorsoapical ⅓ of hind femur, dorsoposteriorly on hind tibia; anterior spiracular fringe light brown; posterior spiracular fringe dark brown; halter brownish or-



Figs. 6–10. Male genitalia, lateral view. 6, *Eristalis persa.* 7, *E. croceimaculata.* 8, *E. alleni.* 9, *E. bellardii.* 10, *E. circe.*

ange, black head; plumula brown; squama large, orange brown, with black margin and fringe; epaulet black and orange pilose; basicosta black pilose; wing bare, light brown.

Abdomen: 1st sternum black, gray pollinose, yellow pilose; 2nd thru 4th sterna orange, rarely black medially, yellow pilose; 1st tergum black, gray pollinose, yellow pilose; 2nd tergum orange except black narrowly apicomedially, orange pilose except black on apical ⅓; 3rd tergum orange except small black basomedial macula, black pilose except orange on basal ¼ and laterally; 4th tergum orange except for very small black basomedial macula, black pilose except for a few scattered intermixed orange pile basally and laterally; genitalia black, dull, yellow and black pilose.

Female.—Similar, but darker; front orangish brown pollinose, black pilose, about .40 times as wide as head at antenna, tapering to about .20 times as wide dorsally; fore femur sparsely black pilose posteriorly; mid and hind femur extensively black pilose; sterna more extensively brownish black; terga more extensively black pilose, 2nd tergum black pilose on apicomedial ½, 3rd tergum entirely black pilose, 4th tergum extensively black pilose, only orange pilose laterally; 5th tergum orange basally, black on apical ⅓, dull pollinose except shiny apically; 5th sternum black, shiny except pollinose apically and laterally.

Type data.—Holotype ♂ from COSTA RICA, Heredia, Braulio Carrillo National Park, Estacion Barva, 2500 m, L-N 233400 523200, Mar 1990, G. Rivera (INBIOCRI000164804), deposited in Instituto Nacional de Biodiversidad, Santo Domingo.

Paratypes: COSTA RICA. Same locality as the holotype but with the following dates and collectors: Sep 1989, G. Rivera (1 ♀ INBIOCRI000111222); Nov 1989, A. Fernandez (1 ♀ INBIOCRI000143385 (USN M)); Dec 1989, A. Fernandez (1 ♂ 1 ♀ INBIOCRI000203524 (USNM), INBIOCRI000290037); Jan 1990, G. Rivera (4♂ 6♀ INBIOCRI000174715, INBIOCRI000174710, INBIOCRI000206578 (USNM), INBIOCRI000206836, INBIOCRI000192229, INBIOCRI000192230 (USNM), INBIOCRI000206813 (USNM), INBIOCRI000206585, INBIOCRI000206580, INBIOCRI000192224); Feb 1990, A Fernandez (INBIOCRI000191262-3, INBIOCRI000191265-6, INBIOCRI000191268-73, INBIOCRI000191287); Feb 1990, G. Rivera (17 ♂ 24 ♀ INBIOCRI000154527, INBIOCRI000202034-5, INBIOCRI000202078-9, INBIOCRI000202082, INBIOCRI000202084-5,INBIOCRI000202087, INBIOCRI000202088 (USNM), INBIOCRI000202089-90, INBIOCRI000202097, INBIOCRI000202105, INBIOCRI000202108-110, INBIOCRI000202114 (USNM), INBIOCRI000202115-6, INBIOCRI000202118, INBIOCRI000202120-1, INBIOCRI000202125-8, INBIOCRI000202130, INBIOCRI000202131 (USNM), INBIOCRI000202132, INBIOCRI000202134-6, INBIOCRI000202140-1, INBIOCRI000202143-5, INBIOCRI000202162 (USNM), INBIOCRI000202168-9, INBIOCRI000202173); Mar 1990, G. Rivera (2 ♂ INBIOCRI000164804 (USNM), INBIOCRI000169585); Mar 1990, A. Fernandez (9 ♀ INBIOCRI000165148,INBIOCRI000165153, INBIOCRI000164394, INBIOCRI000164327 (USNM), INBIOCRI000164461 (USNM), INBIOCRI000169474, INBIOCRI000169479, INBIOCRI000169427, INBIOCRI000169435). *Heredia*: Braulio Carrillo N. P., Transecto, 2050-2600 m, Oct 1989, R. Aguilar & M. Zumbado (1 ♂ 1 ♀ INBIOCRI000131440-1). *Alajuela*: Volcan Poás, 9000 ft., 26 Aug 1966, R. D. Akre (1 ♀ USNM); Volcan Pass, 21 Feb 1980, L. Laverty (2 ♂ 1 ♀ CNC). *Cartago*: Volcan Irazu, 15 Jul 1965, G. Fuentas (1 ♂ USNM). *San Jose*: Villa Mills, 25 May 1979, L. Laverty (1 ♀ CNC), 10 Aug 1979, L. Laverty (1 ♀ CNC); Rancho Rudondo, 1 Dec 1959, A. Wille (1 ♂ WSU); Cerro de la Muerte, 6 km w Villa Mills, Inter-Am H'wy, 3340 m, on flowers of *Seneico* sp. #234, 24 Feb 1972 0830-1100 hours, collector E. R. Heithaus (#10773) (1 ♂ BMNH), 2–3 Jan 1972, E. R. Heithaus, on flowers of *Seneico oerestedianus* (3 ♀ USNM), 25–26 Jan 1972, E. R. Heithaus, on flowers of *Seneico oerestedianus* (1 ♂ 7 ♀ USNM), 23–25 Feb 1972, E. R. Heithaus, on flowers of *Seneico* sp. (6 ♂ 6 ♀ USNM, 1 ♀ CNC), 21 Jul 1971, E. R. Heithaus, on flowers of *Seneico* sp. (1 ♂ USNM), 25 Jul 1971, E. R. Heithaus, on flowers of Roseaceae (2 ♂ USNM), 23–26 Oct 1971, E. R. Heithaus, on flowers of *Seneico oerestedianus* (4 ♂ 4 ♀ USNM), 23–29 Nov 1971, E. R. Heithaus, on flowers of *Seneico oerestedianus* (17 ♂ 10 ♀ USNM, 1 ♂ CNC).

Etymology.—This species is named after Paul Allen, the co-founder of Microsoft in recognition of his contributions to the PC revolution.

Distribution.—*Eristalis alleni* is known only from the central highlands of Costa Rica.

Discussion.—*Eristalis alleni* is similar in appearance to the males of *E. circe* and *E. persa,* but is readily distinguished by its leg color.

Eristalis (*Eoseristalis*) *bellardii* Jaennicke
(Fig. 9, male genitalia)

Eristalis bellardii Jaennicke, 1867: 400. Type-loc.: "Mexico." Syntypes ♂ SMF, Frankfurt. Williston 1892: 60 (key reference, description note, Mexico); Curran 1930: 6, 1934: 410 (key references); Thompson et al. 1976: 101 (catalog citation).

Eristalomyia rufoscutata Bigot, 1880: 221. Type-loc.: "Mexico." Lectotype ♂ UMO (here designated). Synonymy Thompson et al. 1976: 101.

bogotensis of: Giglio-Tos 1893: 4 (description, Mexico); Lynch Arribalzaga 1893: 262 (cit.); Aldrich 1905: 385; Kertész 1910: 214 (in part).

Male.—Head: Black except face sometimes reddish brown laterally; face pale yellowish-white pollinose except for shiny medial vitta which extend ¾ distance to antennal bases, yellow pilose; gena shiny, pale yellow pilose; frontal lunule reddish brown; frontal triangle sparsely pale pollinose, yellow and black pilose; vertical triangle sparsely pollinose, black pilose anteriorly, yellow and black pilose posteriorly; occiput densely white pollinose on ventral ⅔, very sparsely pollinose on dorsal ⅓, white pilose becoming more yellowish on dorsal ⅓, with a few black cilia on dorsal ⅓; antenna black; arista bare, orange; eye pile brownish yellow, white ventrally; eye contiguity long, about 1.5 times as long as vertical triangle.

Thorax: Black, yellow pilose except black pilose on disc of scutellum and rarely with a few black hairs on postalar callus, very sparsely dull pollinose; plumula, halter and squama pale white to yellowish; spiracular fringes brownish yellow; scutellum shiny dark reddish brown. Wing: Epaulet, tegula yellow pilose; basicosta black pilose; hyaline, bare except for a few microtrichia anterobasally on alula. Legs: Extensively black, pale orange only on apices of femora, basal ⅓ to ½ of tibiae and on mid basotarsomere, pale yellow pilose except black pilose on anterior surface of fore and mid femora and posterior surface of hind femur.

Abdomen: Venter ranging from entirely brownish black to extensively reddish orange apically, yellow pilose, shiny except 1st sternum sparsely grayish pollinose. Dorsum yellow pilose except black pilose apicomedially on terga; 1st tergum black; 2nd tergum dull, orange on lateral ⅔, black on medial ⅓, with apical margin yellow; 3rd tergum same as 2nd except for indistinct shiny medial fascia,; 4th tergum orange on basolateral ⅓, black on apicomedial ⅔, extensively dull pollinose, with shiny medial fascia, apical margin yellow; male genitalia black, shiny.

Female.—Similar; front pale yellowish-white pollinose, yellow pilose on ventral ¾, black pilose on dorsal ¼, about .45 times as wide as head at antenna, tapering to about .30 times as wide dorsally; 1st tergum black medially, orange laterally; 3rd tergum orange only on basolateral ⅓ and along apical margin, elsewhere black; 4th tergum black, dull pollinose except for broad shiny meidal fascia; 5th tergum black, shiny medially, dull pollinose on base and apex.

Type data.—*Eristalis rufoscutata* Bigot, lectotype ♂ in The Natural History), London, labelled with "ex. coll. Bigot, Pres. by, G. H. Verrall, B. M. 1894-234." There are another 2 males in The Natural History Museum and 3 more in the Verrall/Collin Collection at Oxford, all of which are labelled paralectotypes.

Material examined.—MEXICO. no further data (1 ♂ BMNH). *Chihuahua*: Sierra Madre, Head of Rio Piedras Verdes, about 7300 ft., C. H. T. Townsend, 21 Jul–11 Sep (1 ♂ 1 ♀ USNM), 27 Jun (1 ♀ BMNH), 3 Jul (2 ♀ BMNH), 17 Jul on *Rhus glabra* (1 ♀ BMNH); 21 Jul (1 ♂ 2 ♀ BMNH), 23

Jul (1 ♂ 3 ♀ BMNH), 29 Aug (2 ♂ 2 ♀ BMNH), 10 Sep "flo 273" [=flower #273?] (1 ♂ BMNH), 11 Sep on *Solidago trinervata* (1 ♂ BMNH), no date (1 ♂ BMNH); *Durango*: El Salto, 10 miles W, 9000 ft., 10 Jun–10 Aug, J. F. McAlpine & J. E. Martin (94 ♂ 105 ♀ CNC); Buenos Aires, 10 miles west La Ciudad, 21 Apr 1961 (1 ♂, 2 ♀ CNC); Navios, 26 miles east El Salto, 8000 ft., (3 ♂, 1 ♀ CNC); La Ciudad, 10 miles west along Mexico highway #40, 8 Nov 1970, D. E. Breedlove (4 ♂ USNM); Ciudad, 8100 ft., Forrer (4 ♂ 6 ♀ BMNH); Huachichilas, 3 miles north, north base of Las Tabletas, Cerros Huehueto, on lumber road, 53 miles north of Coyotes, 9000 ft., on flowers *Eupatorium* and/or *Stevia,* 5 Nov 1970, D. E. Breedlove (1 ♂ USNM). *Jalisco*: Volcan Tequila, 10–14 km SSW of Tequila, 2134 m, 8 Sep 1974, Breedlove (1 ♂ CAS). *Mexico*: Mexico City, Jun 1918, J. Muller (1 ♂ USNM); *Morelos*: Tres Cumbres, 3 road miles south of, 9000 ft., at flowers of *Lopezia minitata,* 16 Jan 1966, D. P. Gregory (1 ♂ USNM). *Oaxaca*: (1 ♂ BMNH). *Chiapas*: San Cristobal de las Casas, 11000 ft., 4 Aug 1962, H. E. Milliron (1 ♀ CNC); 7200 ft., 25 May 1969, Mason (1 ♂ 1 ♀ CNC); 7200 ft., 16 May 1969, Mason (1 ♂ CNC); 7087 ft., 16 May 1969, R. V. Peterson (2 ♂ CNC); 7000 ft., 21 May 1969, H. Teskey (4 ♂ 2 ♀ CNC); San Cristobal de las Casas, 5 miles west, 10 May 1969, J. E. Martin (1 ♂ CNC); San Cristobal, 10 km South, 21 May 1981, C. M. & O. S. Flint (5 ♂ 1 ♀ USNM); Cerro Huitepec, west San Cristobal de las Casas, 2591 m. 23 May 1972, Breedlove (1 ♂ USNM); San Cristobal de las Casas, 7100 ft., 3 Aug 1966, Breedlove (1 ♀ CAS)

Distribution.—*Eristalis bellardii* is restricted to southwestern United States and Mexico, where it ranges from Chihuahua to Chiapas. The northern-most record and only USA record for *E. bellardii* is from southeastern Arizona (Portal). *Eristalis bellardii, E. circe* and *E. persa* are sympatric in Chiapas; *E. bellardii* and *E. circe* are broadly sympatric from Durango to Chiapas.

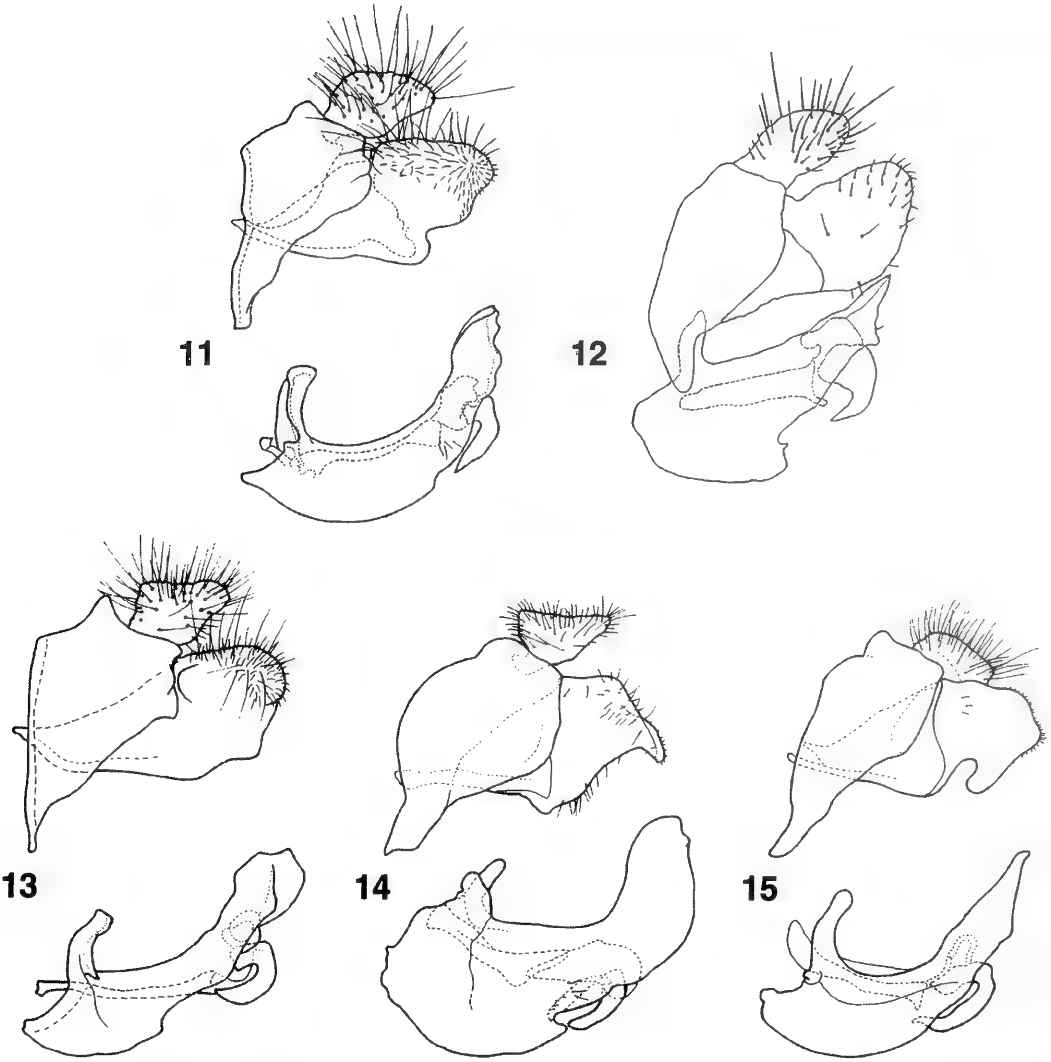
Discussion.—*Eristalis bellardii* represents the northern component of the *E. bogotensis* super species and is distinguished by pale pile on ventral parts of the thorax and coxae and the more extensive red coloration on the abdomen.

Eristalis (*Eoseristalis*) *bogotensis* Macquart
(Fig. 13, male genitalia)

Eristalis bogotensis Macquart, 1842: 112. Type-loc.: Colombia, Santa Fe de Bogota. Lectotype ♀ MNHN, Paris (here designated). Williston 1886: 319 (catalog citation); Wulp 1882a: 79, 1882b: 129 (Argentina); Lynch Arribalzaga 1892: 253, 1893: 262 (description, Argentina); Aldrich 1905: 385 (catalog citation); Brèthes 1907: 293 (catalog citation); Kertész 1910: 214 (catalog citation); Hull 1925: 308, pl. 2:15 (mesonotum figured, key reference, description, Bolivia, Peru); Fluke 1957: 131 (catalog citation, in part); Gaunitz 1969: 75 (male genitalia figured); Thompson et al. 1976: 101 (catalog citation)

Eristalis assimilis Macquart, 1846: 257. Type-loc.: "Colombia." Syntypes ♂♀ Zurich (lost?). Macquart 1850: 499 (in Collection at Lille, Colombia); Schiner 1868: 361 (descriptive note); Williston 1886: 319 (catalog citation); Kertész 1910: 213 (catalog citation); Hull 1925: 308, pls. 1:7, 2:12 (abdomen figured, head figured, key reference, description, Peru); Curran 1930: 6, 1934: 410 (key reference); Fluke 1957: 130 (catalog citation, in part); Etcheverry 1963: 34 (synonymy, Chile?). Synonymy Thompson, et al. 1976: 102.

Male.—Head: Black except face brownish laterally; face shiny except sparsely white pollinose laterally and ventrad antenna, white pilose; gena shiny, white pilose posteriorly; lunule brownish orange; frontal triangle sparsely white pollinose laterally, mainly black pilose, with some white pile



Figs. 11–15. Male genitalia, lateral view. 11, *Eristalis gatesi.* 12, *Palpada semicircula.* 13, *E. bogotensis.* 14, *P. eristaloides.* 15, *E. stipator.*

intermixed laterally; antenna black, black pilose; arista bare, brownish black; eye pile brown; eye contiguity short, as long as vertical triangle, about ¼ as long as frontal triangle; vertical triangle gray pollinose, mainly black pilose, with a few yellow hairs intermixed; occiput densely white pollinose, white pilose with some black cilia on dorsal ⅕.

Thorax: Black except orange humerus, postalar callus and scutellum; mesonotum gray pollinose, mainly yellow pilose with black pile intermixed; pleuron sparsely gray pollinose, yellow pilose except black pilose ventrally; postalar callus yellow pilose; scutellum shiny, yellow and black pilose; squama yellowish orange; spiracular fringes brownish yellow; halter yellow. Wing: Bare, hyaline; tegula yellow and black pilose. Legs: Coxae and trochanters black, black pilose; femora black except yellow apex, yellow and black pilose; tibiae yellow on basal ⅓ to ½, black apically, yellow pilose; tarsi black, yellow pilose.

Abdomen: 1st tergum black, black pollinose, yellow pilose; 2nd tergum orange except for medial black T-shaped macula, dull pollinose, yellow pilose except for a few apicomedial black hairs, with apical margin (incisure) yellow; 3rd tergum orange except black medially and apical margin (incisure) yellow, dull pollinose except for shiny medial fascia, yellow pilose except for black pile apicomedially; 4th tergum black except orange basolaterally and yellow apical margin (incisure), shiny except dull apicomedially, yellow pilose except with a few black hairs apicomedially; sterna black, shiny, yellow pilose; genitalia black, shiny, yellow pilose.

Female.—Similar; front grayish white pollinose laterally, more brownish black pollinose medially, white pilose laterally, yellow and black pilose medially, about .40 times as wide as head at antenna, tapering to about .25 times as wide dorsally; abdomen with black medial area more extensive, 5th tergum and sternum black, shiny, yellow pilose.

Type data.—*Eristalis bogotensis* Macquart, lectotype ♀ #1673 in box 54 of Macquart Collection, Museum National d'Historie Naturelle, Paris, labelled "No 1144, Eristalis, bogotensis" and "E. bogotensis Macq., Bogota." There are no original Bigot/Macquart labels either in Paris, Oxford nor London. There are 3 other females in London and 2♂ 1 ♀ in Oxford. All are labelled as paralectotypes.

Eristalis assimilis Macquart, types (♂♀) in the collection of Marquis de Bréme. 1 ♀ with Macquart/Bigot label in BMNH; another listed for Lille.

Material examined.—COLOMBIA. Meta Dist., 1932, B. Guevara (1 ♂ 1 ♀ USNM); Bogota, B. Guevara (50 ♂ 26 ♀ USNM); Bogota, Dr. A. Balfour, Feb–Apr 1915 (5 ♀ BMNH), Dec 1912 (2 ♂ 1 ♀ BMNH); Bogota, 12 miles southeast, 2930 m, 13 Mar 1955, E. I. Schlinger & E. S. Ross (1 ♂ USNM); Volcan Galeras, Narino, 2400 m, 13 Jan 1959, J. F. G. Clarke (1 ♀ USNM); Atrat Valley, Boca de Arquia, May–Jun 1914 (7 ♂ 4 ♀ BMNH). ECUADOR. Antisamilla to Pinatura, 11000 ft., Ed Whymper (2 ♀ BMNH). Quito, Santa Catalina Expt. Station, 2780 m, 4 Feb 1971 (3 ♂ 7 ♀ USNM); Quito, 2850 ft., F. Campos R. (1 ♂ USNM). *Chimborazo*: Tixan, 8 mi northeast of, 14 Feb 1955, E. I. Schlinger & E. S. Ross (7 ♂ 1 ♀ CAS, USNM); Lago Zurucuchu, 11 miles west of Cuenca, 16 Feb 1955, E. I. Schlinger & E. S. Ross (2 ♂ 8 ♀ CAS, USNM). *Tungurahua*: Ambato, 14 mi northeast of, 2700 m, 8 Feb 1955, E. I. Schlinger & E. S. Ross (1 ♀ ???); Ambato, Nov 1965, J. Foerster (2 ♂ 2 ♀ CNC). *Carchi*: Troya, 11–13 Jun 1965, L. Pena (3 ♂ CNC); Tulcan, 2800m, 27 Jun 1965, L. Pena (1 ♂ 2 ♀ CNC); El Angel, 2700m, 23–25 Jun 1965, L. Pena (7 ♂ 11 ♀ CNC); Tulcan, 10 km southwest of, 2900 m., L. Pena (2 ♂ CNC). Canar, El Tambo, 2800 m, 4–7 Mar 1965, L. Pena (2 ♂ 3 ♀ CNC). *Pichincha*: Pomasqui, 2200 m, 6 Jun 1965, L. Pena (1 ♂ 3 ♀ CNC); Valle de Machachi, 2900 m, 26 Nov 1940, F. Campos R. (2 ♂ 9 ♀ USNM); Machachi, 9-10000 ft., Ed Whymper (1 ♀ BMNH). Loja: west of Loja, 2500 m, 25 Mar 1965 (2 ♂ 10 ♀ CNC). Azuay: Tarqui, 2800 m, 7–8 Mar 1965, L. Pena (2 ♀ CNC); Cuenca, 28 km south of, 2500–2800m, 15 Mar 1965, L. Pena (1 ♂ CNC); Cuena, 2200 m, 10-20 Mar 1965, L. Pena (3 ♂ CNC); Cuena, 2 km north of, 2200 m., 14 Mar 1965, L. Pena (1 ♂ 1 ♀ CNC). PERU. Parish (3 ♂ USNM); Tinco?, Aug 1922, Cockerell (1 ♂ USNM); Orova, 7 May 1914, C. H. T. Townsend (1 ♂ USNM); Matucana, C. H. T. Townsend, 30 Jan 1913 (1 ♂ USNM). *Amazonas*: Cerros Calla-Calla, 45 km east of Balsas, 3100 m, 20 Jun 1964, P. C. Hutchison & K. Wright (1 ♂ USNM). *Arequipa*: 2400 m, Aug–Nov 1936, R. M. Straw (6 ♂ 7 ♀ USNM); Arequipa, 1926, Dr. Escomel (1 ♀ BMNH); Arequipa, 2500 m, 30 Jul–1 Aug 1971 (1 ♂ 1 ♀ BMNH); Cuzco, 3200 m, 20–21 Oct 1962, L. Pena (5 ♂ 4 ♀ CNC); Cuzco, Las Salineras, 17 Sep 1972, J. Escalente (1 ♂ 1 ♀ CNC); Cuzco, Limatambo, 11 Feb 1979, W. E.

Steiner (2 ♂ 1 ♀ USNM); Cuzco, Quispicamchis, Huambutio, 2900 m, 1 Sep 1988, A. Freidberg (1 ♀ USNM); Cuzco, Urubama, 2900 m, 9 Aug 1971, C & M Vardy (2 ♂ BMNH); Cuzco, NW of Cuzco, Barrio Magisterial, C & M Vardy, 3500 m, 7 Aug 1971 (1 ♂ BMNH), 8 Aug 1971 (1 ♂ BMNH); 8 kms S of Cuzco, 3500 m, C & M Vardy, 6 Aug 1971 (1 ♂ 3 ♀ BMNH); Moquequa, Yacango, 8 Oct 1965, J. C. Hitchcock (1 ♂ 1 ♀ USNM). Ancashi: Huaylas, 2800 m., 4 May 1984, P. Hocking (1 ♂ 1 ♀ USNM). *Junin*: 22 Mar 1974, J. Alata (1 ♂ USNM); Huancayo, 3300 m, 13 Sep 1984, P. Hocking (1 ♀ USNM); Tarma, 8 miles west of, 3500 m, 5 Jan 1955, E. I. Schlinger & E. S. Ross (1 ♂ 2 ♀ CAS, USNM). *Huanco*: Panao, 3700 m, 27 Jun 1984, P. Hocking (1 ♀ USNM). *Puno*: Lago Titicaca, 11 Mar 1979, W. E. Steiner (2 ♂ 1 ♀ USNM); Roi, 22 Oct 1965, J. C. Hitchcock (1 ♂ 1 ♀ USNM). Mamara, O. Garlepp c., Coll. W. Schnuse 1911-3 (1 ♀ BMNH); Mamara, Apurimac, 3500 m, 14 Feb 1910 (1 ♀ BMNH). BOLIVIA. *Cochabamba*: Cochabamba, 10 Oct 1966, B. D. Burks (1 ♂ USNM), 14–17 Jun 1942 (3 ♂ USNM); Cochabamba, 2600 m, Schoenfelder, Apr 1950 (1 ♀ BMNH), 10 Apr 1949 (1 ♀ BMNH); Lake Titicaca, 26 Apr 1953, J. A. Munro (1 ♂ USNM); La Paz, O. Garlepp c., Coll. W. Schnuse 1911-3 (1 ♂ BMNH); Altiplano, Pillapi, 70 km east of La Paz, 3780 m, J. L. Chudley, 11 Apr 1964 (1 ♂ BMNH), 5 May 1964 (1 ♂ BMNH); ?Yungas del Palmar, 2000 ft., Schoenfelder (1 ♂ BMNH). ARGENTINA. *Tucumán*: Tucumán, 5 Jul 1917 (1 ♂ USNM); Tucuman, 18 Apr 1913 (1 ♂ USNM); Tucumán, Tafi del Valle, 2100 m, 2–3 Dec 1979, C & M Varley (2 ♀ BMNH); Tafi Viejo, La Toma, 10 Oct 1926 (2 ♂ 1 ♀ USNM). *Mendoza*: 5 Jan 1927, F & M Edwards (1 ♀ BMNH).

Distribution.—*Eristalis bogotensis* is restricted to South America, where it ranges from Colombia to northern Argentina. The southern-most record of *E. bogotensis* is from "Mendoza Prov.," which means that *E. bogotensis* and *E. croceimaculata* are broadly disjunct in distribution. However, more collections for central Chile and Argentina are desired to prove that this disjunction is not an artifact due to lack of collecting. Records of *Eristalis tenax,* which does occur in central Chile, strongly suggest the disjunction is natural.

Discussion.—*Eristalis bogotensis* of authors is a superspecies, which includes *E. bellardii* (USA, Mexico south to El Salvador), *E. bogotensis* (Colombia to northern Argentina) and *E. croceimaculata* (Chile and southern Argentina). The component species are readily distinguished by the extent of pale (red to yellow) maculae on the abdomen and pale pile on the thorax, with the amount of pale color being reduced clinally. The shape of the superior lobe [=paramere of some] and surstyle of male genitalia of all species are also distinctive.

Eristalis (*Eoseristalis*) *circe* Williston
(Fig. 10, male genitalia)

Eristalis circe Williston, 1891: 59. Type-loc.: Mexico, Guerrero, Omilteme, 8000 ft. Lectotype ♂ BMNH, London (here designated). Giglio-Tos 1893: 321 (description, Mexico); Aldrich 1905: 385 (catalog citation); Kertész 1910: 215 (catalog citation); Hull 1925: 25 (key reference, description), 1935: 327 (description, Mexico); Curran 1930: 6, 1934: 410 (key reference); Fluke 1957: 132 (catalog citation); Thompson et al. 1976: 102 (catalog citation).

Eristalis bombusoides Giglio-Tos, 1892: 4. Type-loc.: Mexico, Oaxaca. Syntypes ♂♀ IMZ, Turin. Synonymy by Giglio-Tos 1893: 3.

Eristalis aztecus Hull, 1935: 326. Type-loc.: Mexico, Real del Monte, 9000 ft. Holotype ♂ USNM, Washington. Fluke 1957: 131 (catalog citation); Thompson et al. 1976: 101 (catalog citation) **New synonym**.

Male.—Head: Black; face shiny except sparsely grayish-yellow pollinose ventrad antenna, yellow pilose; gena shiny, yellow pilose; frontal lunule yellow; frontal triangle brownish-yellow pollinose, yellow and black pilose; eye yellow pilose vertically, brown pilose dorsally, with yellow and brown pile medially; eye contiguity short, about as long as vertical triangle, vertical triangle brownish-yellow pollinose, yellow and black pilose; occiput dense grayish-yellow pollinose, white pilose ventrally becoming orange dorsally except with black cilia on dorsal ⅓; antenna brown except orange basoventral ⅓ of basoflagellomere, black pilose; arista distinctly pilose on basal ½, with pile about as long as 2nd antennal segment width.

Thorax: Black except orange scutellum, grayish-brown pollinose; mesonotum with indistinct medial black pollinose vitta; pile orange; squama brownish black; spiracular fringes brown; halter yellow with black knob. Wing: Bare; hyaline except brownish basally; tegula orange pilose. Legs: Coxae and trochanters black, orange pilose; fore and mid femora black except orange on apical ⅕, orange and black pilose; hind femur black except orange apex, shiny, orange and black pilose; fore tibia orange on basal ⅓, black apically, orange pilose; mid tibia orange on basal ⅔, black apically, orange pilose; hind tibia slightly arcuate, black except orange on basal ⅓, black pilose; fore and hind tarsi black, orange pilose; mid tarsus orange on basal 2 tarsomeres, apically black, orange pilose.

Abdomen: 1st tergum black, grayish-yellow pollinose, yellow pilose; 2nd tergum orange except black medial T-shaped macula, orange pilose; 3rd tergum orange except for black quadrate medial maculae, orange pilose; 4th tergum orange, orange pilose; sterna black, yellow pilose; 3rd and 4th sterna with posterior medial edge forming a triangular tooth; genitalia black, orange and black pilose.

Female.—Dissimilar. Head: Similar, front brownish pollinose, black and orange pilose on basal ⅓, orange pilose elsewhere, about .40 times as wide as head at antenna, tapering to about .25 times as wide dorsally. Thorax: Similar. Wings and legs: Similar. Abdomen: Entirely black; 1st tergum gray pollinose, yellow pilose; 2nd tergum shiny except for apical brown pollinose fascia which is interpreted medially, yellow pilose on basal ⅔, brown pilose apically; 3rd and 4th terga shiny except for subapical brown pollinose fasciae, brown pilose; 5th tergum shiny, yellow pilose; sterna black, shiny, white pilose, without apical tooth.

Type data.—*Eristalis circe* Williston, lectotype ♂ in The Natural Museum, London, labelled "Omilteme, Guerrero, 8000 ft., Jul H. H. Smith," "Biol. Centr. Amer., Dipt.-Syrphidae, F. D. Godman, O. Salvin, 1903-51" and "Eristalis, circe, Williston" [a Williston bordered determination label]. There are another 2 males labelled as paralectotypes in London, but there are none in New York.

Eristalis azteca Hull, holotype ♀ the National Museum of Natural History, Washington, labelled "Real del Monte, Mex. El 9,000'," "Coll. by H. T. Vanastrand," "Coll. of W. R. Walton," "Eristalis, montanus, Will.," "Eristalis, aztecus, n. sp." [determination label in Hull's hand" and "Type No., 42076, U.S.N.M." [Red USNM type label]. The type of *aztecus* Hull is a pale immature specimen with brownish orange maculae on 2nd tergum like *tenax,* otherwise the specimen agrees well with my concept of *circe.*

Material examined.—MEXICO. Cerrapotosi, 4 Mar 1964, J. F. Reinert (2 ♂ USNM); Real del Monte, 9000 ft., H. T. Vandstrand (1♂ USNM). *Durango*: La Ciudad, 24 miles west of, 7000 ft., 2 Jul 1964, J. F. McAlpine (1 ♂ CNC); Buenos Aires, 10 miles west of La Ciudad, 9000 ft., 8 May 1961, H. Howden & J. Martin (1 ♂ CNC); El Salto, 10 miles west of, 9000 ft., 10 Aug 1964 (CNC), 12 Jun 1965, J. McAlpine (CNC), 30 Jun 1964, J. Martin (CNC). *México*: Mexico City, J. Muller (1 ♂ USNM). *Morelos*: Huitzilac, 25 Jul 1978, J. Butze (2 ♂ 1 ♀ UNAM); Tetela del Volcan, 15 Jun 1978, G. Arzate (1 ♀ UNAM).

Oaxaca: Ixtlan de Juarez, 13 miles northeast of, on Rigidella, 25 Jul 1966, Molseed, Baptista & Kirchanghi (1 ♂ 1 ♀ CAS); Sierra de Miahuatlan, 2 km southeast of San Jose del Pacifico, 2438 m, 29 Oct 1974, Breedlove (3 ♂ CAS, USNM). *Chiapas*: San Cristobal, 8 miles northeast of, 7500 ft., 9 May 1969, H. Teskey (1 ♂ CNC); 6 May 1969, J. E. Martin (1 ♀ CNC); Mt. Tzontehuitz, 9500 ft., 27 May 1969, H. Teskey (2 ♂ 4 ♀ CNC, USNM). EL SALVADOR. Monte Cristo, 2418 m., 3 Mar 1978, D. R. Barger (1 ♂ USNM), 26 Mar D. R. Barger (4 ♂ USNM), 25 Apr 1977, D. R. Barger (1 ♂ USNM), 24 May 1977, D. R. Barger (1 ♂ USNM), 28 Jun 1977, D. R. Barger (1 ♂ USNM), 10 Sep 1977, D. R. Barger (1 ♂ USNM); 13 Sep 1977, D. R. Barger (1 ♂ 1 ♀ USNM), 15 Sep 1978, D. R. Barger (1 ♀ USNM).

Distribution.—*Eristalis circe* is found in Mexico (north to Durango) and northern Middle America (El Salvador), is broadly sympatric with *E. bellardii,* and occurs with *E. persa* in Chiapas.

Discussion.—*Eristalis circe* and *E. persa* are very similar in appearance, but are readily separated by their leg color. In both species, the sexes are strongly dissimilar, the males having orange colored abdomens and the females having black colored abdomens. Most *Eristalis* species are monomorphic, but *E. arbustorum* Linnaeus and *E. brousi* Williston (two north temperate species) are also dimorphic. Hence, this species pair may represent the sister group to the *bogotensis* super species.

Eristalis (*Eoseristalis*) *croceimaculata* Jacobs
(Fig. 7, male genitalia)

Eristalis croceimaculata Jacobs, 1900: 107. Type-loc.: Argentina, Tierra del Fuego, Isla de los Estados, Golfe Saint-Jean. Holotype ♀ IRSNB, Brussels. Jacobs 1906: 69, pl. 3, fig. 3 (habitus, Argentina); Brèthes 1907: 293 (catalog citation); Kertész 1910: 216 (catalog citation); Shannon & Aubertin 1933: 122 (?*bogotensis*); Fluke 1957: 133 (catalog citation).

Palpada croceimaculata: Thompson et al. 1976: 104 (catalog citation).

bogotensis of: Lynch Arribálzaga 1892: 253, 1893: 262 (Argentina); Shannon & Aubertin 1933: 162 (description note, Chile, Argentina); Stuardo 1946: 128 (catalog citation, Chile); Fluke 1957: 130 (in part); Etcheverry 1963: 34 (synonymy, Chile)

Male.—Head: Blackish brown except face brownish yellow laterally; face shiny except sparsely white pollinose laterally and ventrad antenna, yellow pilose except for a few black hairs dorsolaterally; gena shiny, white pilose posteriorly; lunule yellowish orange; frontal triangle sparsely white pollinose laterally, mainly black pilose, with some yellow pile intermixed laterally; antenna black, black pilose; arista bare, brownish black; eye pile brown; eye contiguity short, ½ as long as vertical triangle, about ⅓ as long as frontal triangle; vertical triangle gray pollinose, mainly black pilose, with a few yellow hairs intermixed; occiput densely white pollinose, white pilose ventrally, becoming yellow pilose dorsally, with some black cilia on dorsal ⅕.

Thorax: Black except orange humerus, postalar callus and scutellum; mesonotum gray pollinose with indistinct submedial black pollinose vittae, mainly yellow pilose with black pile intermixed; pleuron sparsely gray pollinose, yellow pilose except black pilose ventrally; postalar callus yellow pilose; scutellum shiny, yellow and black pilose; squama yellowish orange; spiracular fringes dirty white; halter yellow. Wing:—Bare, hyaline; tegula yellow and black pilose. Legs: Coxae and trochanters black, black pilose; femora black except yellow apex, yellow and black pilose; tibiae yellow on basal ⅓ to ½, black apically, yellow pilose; tarsi black, yellow pilose.

Abdomen: 1st tergum black, black pollinose, yellow pilose; 2nd tergum orange except for medial black transverse H-shaped macula, dull pollinose, yellow pilose except for a few apicomedial black hairs, with apical margin (incisure) yellow; 3rd tergum black except orange basolaterally and yellow apical margin (incisure) yellow, dull pollinose except for shiny medial fascia, yellow pilose except for black pile posteriorly; 4th tergum black except yellow apical margin (incisure), shiny except dull apicolaterally, black pilose except yellow pilose basolaterally; sterna brownish black, shiny, yellow and black pilose; genitalia black, shiny, yellow and black pilose.

Female.—Similar; front grayish white pollinose laterally except shiny anteriorly, white pilose, about .40 times as wide as head at antenna, tapering to about .25 times as wide dorsally; abdomen with black medial areas more extensive, 3rd tergum entirely black, 5th tergum and sternum black, shiny, black pilose.

Type data.—Holotype ♀ in the Institut Royal des Sciences Naturelles des Belgique, Brussels, labelled "♀," "107," "Ile des Etats, Argentine, 8. I. 1897," "Eristalis, #5, crocei-, maculata J," "Eristalis, croceimaculata J., det. Jacobs," "TYPE [pink]," "cf. Expéd. Antaret. Belg., (Belgica) Zool. (Ins.), 1906 p. 69 -10," "Reg. Mus. Hist. Nat., Belg. I. G. 10131," and "Eristalis croceimaculata, J." The type is double-mounted and in good condition, only the antennae are missing. The apical tarsomere of the hind leg is mounted separately and labelled "A. Collart vid. , 1934:, onote de la patte, poste,rieure, droite d'Eristalis, croceimacutata J." and "Reg. Mus. Hist. Nat., Belg. I. G. 10131."

Material examined.—ARGENTINA. *Chubut*: Valle del Lago Blanco, J. Koslowsky, 1904-26 (2 ♂ BMNH). *Rio Negro,* Bariloche, 25-28 Oct 1926, F & M Edwards (1 ♀ BMNH), Nov 1926, R. & E. Shannon (10 ♂ 1 ♀ USNM), 1 Dec 1926, F. & M. Edwards (1 ♂ USNM); Lake Gutierrez, 3-14 Nov 1926, F & M Edwards (3 ♂ BMNH); Lake Nahuel Huapi, Eastern End, 1 Nov 1926, F & M Edwards (3 ♂ 2 ♀ BMNH). *Tierra del Fuego,* Rio Grande, Estancia Viamonte, P. W. Reynolds (4 ♂ 1 ♀ BMNH). FALKLAND ISLANDS. Port Stanley, Nov 1984–Feb 1985 (1 ♂ BMNH); East Falklands, Stanley area, Maj. C. Kirke, Nov 1986 (7 ♂ 2 ♀ BMNH), 1–15 Dec 1986 (9 ♂ 3 ♀ BMNH), 14–31 Dec 1986 (2 ♂ 5 ♀ BMNH), Jan 1987 (3 ♀ BMNH). CHILE. "R. N. El Bolson," 30 Nov 1961, A. Kovacs (1 ♀ BMNH). *Aysen*: Chico, Lag. Buenos Aires, 24–31 Dec 1960, L. Pena (3 ♀ CNC); Puerto Cisnes, 72°40'W 44°45', 16-28 Nov 1960, L. Pena (1 ♀ CNC); Coihaique, Rio Simpson, 23–24 Jan 1961, L. Pena (1 ♀ CNC), 7–9 Mar 1961, L. Pena (1 ♀ CNC). *Magallanes*: Lag. Amarga, Natales, east of Mt. Payne, 200 m, 14–20 Dec 1960, L. Pena (1 ♂ CNC); Lena Dura, 4 Dec 1932, E. P. Reed (1 ♂ USNM). Tierra del Fuego: Punta Arenas, 40 km northeast of, 11 Dec 1960, L. Pena (1 ♂ CNC); Puerto Williams, Isla Navarino, 22–29 Nov 1960, L. Pena (1 ♀ CNC); Punta Arenas, 9–15 Jan 1966, Flint & Cekalovic (1 ♀ USNM), 3 Mar 1959, J. E. F. Clarke (1 ♂ 1 ♀ USNM). *Malleco*: Marimenuco, 1100 m., 10–13 Dec 1959, L. Pena (1 ♀ CNC). *Llanquihue*: Puerto Varas, Dec 1926, R. & E. Shannon (2 ♂ USNM); Casa Panque, F & M Edwards, 4–10 Dec 1926 (1 ♂ 2 ♀ BMNH).

Distribution.—*Eristalis croceimaculata* is restricted to south temperate regions of South America, being found in Chile and south Argentina. The northern-most record for *E. croceimaculata* is from Marimenuco in Malleco (Chile). The type-locality on Staten Island makes it one of the southernmost recorded flower fly. No other eristaline flower fly is known from so far south. However, when a Smithsonian group visited Staten Island in 1971, no flower flies were found.

***Eristalis (Eoseristalis) gatesi* Thompson, new species**

(Fig. 2, habitus; 11, male genitalia)

Male.—Head: Face tawny brown except broadly black along oral margin and with black medial vitta extending over tubercle, brown pollinose, with pollinosity sparse on black areas, yellow pilose; gena black, sparsely gray pollinose, yellow pilose posteriorly; frontal lunule orange; frontal triangle black, gray pollinose, yellow pilose with a few black hairs intermixed; eye pile brown; eye contiguity long, as long as vertical triangle, about ¾ as long as frontal triangle; antenna orange except narrowly brownish black on dorsal edge of basoflagellomere, black pilose; arista orange, sparsely pilose on basal ½, with 5-6 long dorsal hairs and more short vertical ones, with dorsal hairs about as long as 2nd antennal segment width; occiput densely white pollinose, yellowish white pilose ventrally becoming yellow orange dorsally, with black cilia on dorsal ¼.

Thorax: Black; mesonotum gray pollinose, without pattern, yellow pilose except with black pile intermixed posteriorly; pleuron gray pollinose, black pilose except with yellow pile intermixed on episternum; postalar callus black pilose; scutellum brown pollinose, black pilose; squama black; halter gray with black knob; spiracular fringes black. Wing: Fumose basally, hyaline apically, bare; tegula black pilose. Legs: Black, black pilose except yellow pilose on fore tibia and fore and mid tarsi; hind femur narrow, very slightly arcuate, without short black apicoventral spinose hairs.

Abdomen:—1st tergum black, black pollinose, black pilose; 2nd tergum yellow except black T-shaped basomedial macula and black basolaterally, black pilose except for a few yellow hairs basomedially; 3rd tergum yellow except for black T-shaped apicomedial macula, black pilose; 4th tergum black, black pollinose except shiny medial macula, black pilose; genitalia black, sparsely black pollinose, black pilose; 1st sternum black, gray pollinose, black pilose except for a few yellow apicomedial hairs; 2rd and 3rd terga yellow except narrowly black medially, shiny, yellow pilose; 4th sternum black, shiny, black pilose except yellow pilose apicomedially.

Female.—Similar except abdomen more extensively black; front brown pollinose, brownish orange pilose, about .40 times as wide as head at antenna, tapering to about .20 times as wide dorsally; 2nd tergum black except narrowly yellow apically, black pollinose except yellow on apical margin, entirely black pilose; 3rd tergum yellow except black laterally and medially, black pilose; 4th tergum as in male; 5th tergum black, black pollinose basally, shiny apically, black pilose; 2nd thru 5th sterna black, shiny, black pilose.

Type data.—Holotype ♂ from Costa Rica, Heredia, Braulio Carrillo National Park, Estacion Barva, 2500 m, L-N 233400 523200 G. Rivera (INBIOCRI000139939). In Instituto Nacional de Biodiversidad, Santo Domingo.

Paratypes: COSTA RICA. Same locality as the holotype but with the following dates and collectors: Sep 1989, G. Rivera (2♂ INBIOCRI000111006, INBIOCRI000111219); Oct 1989, G. Rivera & A. Fernandez (5 ♀ INBIOCRI000108636, INBIOCRI000108635 (USNM), INBIOCRI000108634, INBIOCRI000108683 (USNM), INBIOCRI000108684); Nov 1989, A. Fernandez (1 ♂ INBIOCRI0001433650); Nov 1989, G. Rivera (2 ♂ 1 ♀ INBIOCRI000139937 (USNM), INBIOCRI000139932, INBIOCRI000140172 (USNM)); Dec 1989, A. Fernandez (1 ♀ INBIOCRI000290043); Jan 1990, G. Rivera (2 ♂ 4 ♀ INBIOCRI000192196 (USNM), INBIOCRI000206816, INBIOCRI000206810, INBIOCRI000206807, INBIOCRI000174448, INBIOCRI000192232); Feb 1990, A. Fernandez (1 ♂ 2 ♀ INBIOCRI000191254-6); Feb 1990, G. Rivera (1 ♂ 4 ♀ INBIOCRI000202149 (USNM), INBIOCRI000202137, INBIOCRI000202107, INBIOCRI000202139, INBIOCRI000202172, INBIOCRI000202148); Mar 1990, A. Fernandez (1 ♀ INBIOCRI000169656 (USNM); Mar 1990, G. Rivera (1 ♀ INBIOCRI000164807); Apr 1989, M. Zumbado & A. Fernandez (INBIOCRI000052536). *Limon*: Cerro Chirripo, 2 Aug 1987, A. Solis (1 ♀ INBIO0001007910). *Alajuela*: Volcan Pass, 21 Feb 1980, T. Laverty (1 ♂ CNC);; Volcan Poás, 9000 ft., 26 Aug 1966, R. D. Akre (2 ♂ USNM, WSU). *San Jose*: Cerro de la Muerte, 2 Mar 1980, T. Laverty (1 ♀ CNC); Cerro de la Muerte, 10,000 ft., 24 Aug 1970, R. W. Merritt (1 ♀ WSU); Cerro de la Muerte, 6 km w Villa Mills, Inter-Am H'wy, 3340 m, on flowers of *Seneico oerestedianus* Benth #234, 23 X 1971 0715-1030 hours, collector E. R. Heithaus (#10773) (1 ♂ BMNH), 3 Jan 1972, E. R. Heithaus, on flowers *Senecio oerestdianus* (4 ♂ 3 ♀ USNM, 1 ♂ 1 ♀ CNC), 25–27 Jan 1972, E. R. Heithaus, on flowers *Senecio oerestdianus* (5 ♂ 10 ♀ USNM), 23 May 1972, E. R. Heithaus, on flowers *Senecio* sp. (1 ♀ USNM), 25 Aug 1971, E. R. Heithaus, on flowers Rosaceae (3 ♂ USNM), 23 Aug 1971, E. R. Heithaus, resting on ground, overcast sky 18°C (1 ♀ USNM), 18 Aug 1971, E. R. Heithaus, resting on *Vaccinium* (1 ♀ USNM), 23–26 Oct 1971, E. R. Heithaus (1 ♂ 4 ♀ USNM), 24 Nov 1971, E. R. Heithaus (6 ♂ USNM).

Etymology.—This species is named after William Gates, III, the co-founder of Microsoft in recognition of his contributions to the PC revolution.

Distribution.—*Eristalis gatesi* is known only from the central highlands of Costa Rica.

Discussion.—The black and yellow abdominal color pattern of *E. gatesi* is unique among eristaline flower flies.

Eristalis (*Eoseristalis*) *persa* Williston
(Fig. 6, male genitalia)

Eristalis persa Williston, 1891: 58. Type-loc.: Mexico, Guerrero, Sierra de las Aguas Escondidas, 9000 ft. Holotype ♀ BMNH, London. Aldrich 1905: 388 (catalog citation); Kertész 1910: 229 (catalog citation); Hull 1925: 24 (key reference, description); Fluke 1957: 140 (catalog citation); Thompson et al. 1976: 102 (catalog citation).

Male.—Head: Black; face shiny except sparsely grayish-yellow pollinose ventrad antenna, yellow pilose; gena sparsely grayish-yellow pollinose, yellow pilose; frontal lunule yellow; frontal triangle brownish-yellow pollinose, yellow and black pilose; eye yellow pilose; eye contiguity short, about as long as vertical triangle, vertical triangle brownish-yellow pollinose, yellow and black pilose; occiput dense grayish-yellow pollinose, with a brown pollinose macula on ventral ¼, yellow pilose except with black cilia on dorsal ⅓; antenna orange, black pilose; arista distinctly pilose on basal ½, with pile about as long as 2nd antennal segment width.

Thorax: Black, grayish-brown pollinose; mesonotum with medial and submedial black pollinose vittae, with vittae indistinct anteriorly; pile dark orange, intermixed black and orange on scutellum and postalar callus; squama and halter brownish black; anterior spiracular fringe brown, posterior spiracular fringe brownish black. Wing: Bare; hyaline except brownish basally; tegula orange pilose. Legs: coxae and trochanters black, orange pilose; fore and mid femora black except orange on apical ⅓, orange pilose; fore femur with dense tuft of black pile on posterobasal ¼; hind femur black, shiny, mainly orange pilose, with some scattered black pile intermixed; fore and mid tibiae orange, orange pilose; hind tibia slightly arcuate, black except orange basally and on apical ¼, black pilose; tarsi orange, orange pilose.

Abdomen: 1st tergum black, grayish-yellow pollinose, yellow pilose; 2nd tergum orange except black medial T-shaped macula, orange pilose; 3rd and 4th terga orange except for black quadrate medial maculae, orange pilose; sterna brownish orange, orange pilose; genitalia black, orange and black pilose.

Female.—Dissimilar. Head: Similar except more extensively black pilose on front; front about .35 times as wide as head at antenna, tapering to about .20 times as wide dorsally. Thorax: Similar except more extensively black pilose; pleuron extensively black pilose except anepisternum extensively yellow pilose; mesonotum with posterior ½ black pilose except narrowly laterally and posteriorly orange pilose; scutellum and postalar callus entirely black pilose. Wings and legs: Similar except without black pile tuft on fore femur. Abdomen: Entirely black and black pilose.

Type data.—Holotype ♀ in The Natural History Museum, London, labelled "Sierra de las Aguas Escondidas, Guerrero, 9500 ft., Jul H. H. Smith," "Biol. Centr. Amer., Dipt.-Syrphidae, F. D. Godman, O. Salvin, 1903-51" and "Eristalis, persa, Williston" [a Williston bordered determination label].

Material examined.—MEXICO. Santa Ana, 9 Jan 1957, P. A. B. (1 ♀ USNM), 16 Oct 1956, P. A. B. (1 ♂ USNM). *Chiapas*: Municipio Las Margaritas, 48 km northeast Las Margaritas on road to Campo Alegre, 2134 m, 25 Oct 1976, D. E. & J. A. Breedlove (1 ♀ USNM). EL SALVADOR. Monte Cristo, 26 Mar 1978, D. R. Barger (1 ♂ USNM).

Distribution.—*Eristalis persa* is known only from southern Mexico (Chiapas) and El Salvador and is sympatric with *E. bellardii* and *E. circe* in Chiapas.

Discussion.—Williston and subsequent authors did not know the male. The species is dimorphic like *E. circe* (*q.v.*). The male of *E. persa* is readily distinguished from all other *Eristalis* species by having a tuft of long black pile on the base of the fore femur.

Eristalis (*Eoseristalis*) *stipator* Osten Sacken
(Fig. 15, male genitalia)

Eristalis latifrons Loew, 1866: 169 (preocc. Zetterstedt, 1843). Type-loc.: Mexico, Matamoros. Lectotype ♂ MCZ, Cambridge (here designated). Williston 1892: 60 (key reference, Mexico); Giglio-Tos 1893: 5 (description, Mexico); Aldrich 1905: 386 (catalog citation); Kertész 1910: 224 (catalog citation); Hull 1925: 295 (key reference, description); Curran 1930: 6, 1934: 410 (key reference); Fluke 1957: 137 (catalog citation).

Eristalis stipator Osten Sacken, 1877: 336. Type-loc.: USA, Colorado, Manitou Park. Lectotype ♂ MCZ, Cambridge (here designated). Thompson et al. 1976: 102 (catalog citation).

Eristalis latifrons var. *maculipennis* Townsend, 1897: 93. Type-loc.: USA, New Mexico, Las Cruces. Lectotype ♀ USNM, Washington (here designated). Townsend 1895: 49 (descriptive note); Aldrich 1905: 387 (catalog citation); Kertész 1910: 224 (catalog citation).

Male.—Head: Black; face densely white pollinose except shiny medially on tubercle, white pilose; gena shiny, white pilose posteriorly; frontal lunule brownish black; frontal triangle white pollinose, shiny apicomedially, white pilose; vertical triangle sparsely brownish pollinose, yellow and black pilose; eye white pilose; eye contiguity long, about ⅓ longer than vertical triangle; occiput densely white pollinose, white pilose ventrally becoming more yellow on dorsal ¼.

Thorax: Black except orange scutellum, shiny, orange pilose dorsally, yellow pilose on pleuron; halter yellow; squama white; spiracular fringes white. Wing: Bare, hyaline, tegula yellow pilose. Legs: Coxae and trochanters black, yellow pilose; femora brownish black except yellow apical ⅕, yellow pilose except with some black pile anteroventrally on mid and hind femora; fore tibia orange on basal ⅔, brownish black apically, yellow pilose; mid tibia orange on basal ¾, brownish black apically, yellow pilose; hind tibia orange on basal ½, brownish black apically, yellow pilose except with black pile intermixed on apical ½; fore tarsus brown, yellow pilose; mid tarsus yellow on basal ¾ of 1st tarsomere and basal ½ of 2nd tarsomere, brown elsewhere, with pale areas with yellow pile, with yellow and black pile elsewhere; hind tarsus black, yellow pilose except with black pile intermixed anteriorly.

Abdomen: 1st tergum brown, grayish-white pollinose, white pilose; 2nd tergum brown-black medially in form of X-shaped macula, yellow elsewhere, shiny except for brown pollinose apicomedial fascia and white pollinose apical margin (incisure), yellow pilose on basal ⅔ and laterally, black pilose on apicomedial ⅓; 3rd tergum brown, with or without medial transverse orange macula, shiny except narrowly white pollinose along anterior margin and apical margin (incisure), yellow pilose; 4th tergum shiny except narrowly white pollinose along anterior margin and apical margin (incisure), brownish-black except yellowish-white apical margin, white pilose; genitalia brownish black, shiny, yellow pilose; 1st sternum brown, gray pollinose, yellow pilose; 2nd sternum brownish medially, yellow laterally, shiny, yellow pilose; 3rd and 4th sterna brownish black, shiny, yellow pilose.

Female.—Similar; front entirely white pilose, about .45 times as wide as head at antenna, tapering to about .30 times as wide dorsally; 5th tergum and sternum black, yellow pilose.

Type data.—*Eristalis latifrons* Loew, lectotype ♂ in Museum of Comparative Zoology, Cambridge, labelled "Mat," "Loew Coll," "Type, 4073" and "Eristalis, latifrons, m." [in Loew's hand].

Eristalis stipator Osten Sacken, lectotype ♂ in Museum of Comparative Zoology, Cambridge, labelled "Manitou, Park," "Osten, Sacken, Coll.," "Type, 7,885" and "latifrons." There are another 8 specimens from various localities that have been labelled as paralectotypes.

Eristalis latifrons var. *maculipennis* Townsend, lectotype ♀ in National Museum of Natural History, Washington, labelled "Las Cruces, 6.7 N.M." and "Coll. Townsend." No other syntypes were found. George Byers carefully checked the Snow Museum collections, where additional material should have been deposited. While this variety was formally named in 1897, Townsend referred back to his description of it in his 1895 paper. Hence, the type series consists of the female mentioned in the 1897 as well as those mentioned in the earlier paper. The Las Cruces material of his 1895 paper is undoubtedly what he refers to as "numerous specimens from Mesilla valley of the Rio Grande" in his 1897 paper.

Material examined.—MEXICO. *Chihuahua*: Sierra Madre, Head of Rio Piedras Verdes, about 7,300 ft., 3 Jul, C. H. T. Townsend (1♂ USNM); same locality, but "9.6" (1 ♀ USNM). Also, numerous specimens from the United States were examined.

Distribution.—*Eristalis stipator* is found in southern Canada (British Columbia to Nova Scotia), throughout the United States and in northern Mexico. The above record is the southern-most for the species.

OTHER SPECIES

A few other species of *Eristalis* have been erroneously reported from the neotropics. *Eristalis arbustorum* and *E. transversa* were incorrectly recorded from Jamaica (Thompson 1981: 147). Macquart (1842: 32) described *Eristalis quadelupensis* from Guadeloupe which was based on an apparently mislabeled specimen of *E. pertinax* (Scopoli)(Thompson 1981: 146). Likewise, Bigot (1880: 217) described *E. inca* from Peru. Verrall (1901: 514; Kertész 1910: 230) noted that the name was based on a specimen of *E. pertinax,* an identification which has been confirmed recently (Nielsen, in litt.). The following two *Palpada* species are treated here as they may be confused with *Eristalis* species due to their bare katepimera.

***Palpada eristaloides* Thompson, new species**

(Fig. 14, male genitalia)

Male.—Head: Face brownish yellow, yellow pollinose except shiny medial vitta, yellow pilose; gena yellow brown, shiny, yellow pilose posteriorly; occiput white pollinose and pilose on ventral ¾, more grayish pollinose on dorsal ¼, black pilose dorsally; frontal lunule yellow; front dark, brownish black pollinose except more yellowish pollinose laterally along eye margin, black pilose; frontal triangle yellow, yellowish-white pollinose, black pilose; vertex black, brownish-black pollinose, black pilose; eye black pilose on dorsal ½, yellow pilose ventrally; eye contiguity short, about ⅓ as long as vertical triangle; eyes dichoptic, separated by distance equal to aristal width; antenna orange, orange pilose except for a few long black bristle-like hairs on 2nd segment; basoflagellomere with a large basoventral sensory pit on mesal surface; arista brownish black, bare.

Thorax: Black; mesonotum generally dull black pollinose, with pale grayish-white pollinose pattern, black pilose medially, dark brownish-orange pilose anteriorly and laterally; mesonotal pale areas anteriorly and laterally, on transverse suture, and in form of broad submedial vittae which extend ⅔ distance to scutellum; postalar callus dark brownish-black pilose; scutellum yellowish orange, slightly brownish black basomedially, black pilose; pleuron gray pollinose, brownish-orange pilose; ampulla orange; plumula and halter yellow; squama brownish black on dorsal lobe and brown on margin of ventral lobe, yellowish orange elsewhere; spiracular fringes white. Wing: Hyaline, bare except microtrichose posterior to stem vein and basoanterior corner of alula. Legs: Coxae black, gray pollinose, yellow pilose; trochanters black, shiny except fore trochanter gray pollinose, yellow pilose; hind trochanter with dense apical tuft of black setulae; fore and mid femora blackish brown except yellow apically, yellow on apical ½ anteriorly, apical ¼ posteriorly, yellow pilose; hind femur arcuate, blackish brown except yellow on apical ¼, yellow pilose with short black spinose hairs ventrally; tibiae yellow, yellow pilose; hind tibia with ventromedial carina on basal ¼, with apicolateral spinose setal patch; fore tarsus black except yellow basotarsomere, yellow pilose; mid and hind tarsi black except yellow basotarsomere and basal ½ of 2nd tarsomere, yellow pilose.

Abdomen: 1st tergum yellow except brown on medial ⅓, gray pollinose, yellow pilose; 2nd tergum dull yellowish orange except black medial T-shaped maculae and apicolateral corners, yellowish orange pilose except for a few black hairs apicomedially; 3rd tergum dull black except large orange basolateral maculae on basal ⅔ and yellow apical margin, black pilose except for a few longer lateral yellow hairs; 4th tergum dull black except yellow apical margin, black pilose; 5th tergum black, shiny on apical ½, dull black pollinose on basal ½, black pilose; 1st sternum reduced, yellow, sparsely white pollinose, yellow pilose; 2nd thru 4th sterna yellow, slightly more brownish medially and laterally, shiny, yellow pilose; 5th tergum black, shiny, yellow pilose.

Female.—Similar; front entirely black pilose, dark brown pollinose medially and entirely on dorsal ⅓, light tan pollinose laterally on ventral ⅔, brown pollinose elsewhere, about .35 times as wide as head at antenna, tapering to about .15 times as wide dorsally. Legs: Darker, basal ⅔ of front and middle femora brown, basal ¾ of hind femur brown, hind tibia and trochanter without black setal patches or tufts; 5th tergum brownish black, black pollinose on basal ½, shiny apically.

Type data.—Holotype ♂ in Canadian National Collection, Ottawa, labelled ECUADOR: Carchi, 10 km SW Tulcan, 2900 m, 28 Jun 1965 (L. Peña).

Paratypes: ECUADOR. Carchi, Troya, 2950 m, 11-13 Jun 1965 (L. Pena) 1 ♂ (USNM); Azuay, Cerro Tinajillas, 3100 m, 18-21 Mar 1965 (L. Peña) 1 ♀ (CNC); Napo, 0°22'S 78°8'W, 3500 m, 4–7 Mar 1976 (G. & M. Wood) 2 ♀ (CNC, USNM).

Etymology.—This species is named *eristaloides* as it is phenotypically like *Eristalis* in having the katepimeron bare.

Distribution.—*Palpada eristaloides* is known only from high elevations in Ecuador.

Discussion.—*Palpada eristaloides* is distinctive with its mesonotal pollinose pattern and bare katepimeron.

Palpada semicircula Walker
(Fig. 12, male genitalia)

Eristalis semicirculus Walker, 1852: 249. Type-loc.: Honduras. Lectotype ♂ BMNH, London (here designated). Williston 1892: 78 (citation); Wulp 1896: 114 (East Indies [error]), 1899: 52 (correction of previous error); Aldrich 1905: 389 (catalog citation); Kertész 1910: 235 (catalog citation); Fluke 1957: 143 (catalog citation).

Palpada semicirculus: Thompson et al. 1976: 109 (catalog citation).

Eristalis tenuifrons Curran, 1930: 12. Type-loc.: Panama, Canal Zone, Fort Randolph. Holotype ♀ AMNH, New York. Curran 1934: 409 (key reference); Fluke 1957: 145 (catalog citation); Thompson et al. 1976: 102 (catalog citation). **New synonym**.

Male.—Head: Black; face white pollinose except for shiny narrow medial vitta, white pilose; gena shiny; frontal triangle shiny apicomedially, white pollinose elsewhere, black pilose medially, white pilose laterally; vertical triangle gray pollinose anteriorly, black pollinose on ocellar triangle, black pilose; occiput densely white pollinose and pilose on ventral ⅔, more brownish black pollinose and black pilose dorsally; antenna black pilose; scape and pedicel brownish orange; basoflagellomere orange-brown on basoventral ⅓, brownish black elsewhere; arista bare; eye pile short, white; eyes narrowly dichoptic, separated by about basal width of arista.

Thorax: Black, extensively yellowish white pilose, black pilose on scutellum and postalar callus, with some intermixed black pile on posterior ½ of scutum; mesonotum dull black pollinose except broadly gray pollinose anteriorly, laterally, across transverse suture and anterior to scutellum; gray pollinose areas appear as 2 broad anterior fasciae connected to a large U-shaped macula posteriorly; pleuron gray pollinose, with pollinosity densest on katepisternum; scutellum yellow except black basal ⅓; halter orange; plumula white; squama white with black margin and yellow apical fringe; spiracular fringes dirty white. Legs: Black except brownish orange femoral-tibial joints, pale pilose except black pile on anterior and ventral surfaces of mid tibia, black pilose on anterodorsal surface of fore and mid femora, black pilose on apex and apicoventral margin of hind femur and black pilose on tarsi; hind femur swollen; hind tibia with ventromedial carina on apical ½ in addition to basoventral carina; hind trochanter with only normally white pile; epaulet black pilose except for some orange pile; tegula brown pilose; basicosta black pilose; wing hyaline, bare except for a few widely scattered microtrichia apically and posteriorly.

Abdomen: Sterna 1, 3 and 4 black, gray pollinose, white pilose; sternum 2 yellow, shiny, white pilose; 1st tergum black, gray pollinose, white pilose; 2nd tergum extensively black, dull black pollinose, white pilose, with large subtriangular shiny yellow basolateral macula and yellow apical margin (incisure), with macula narrowly separated from lateral margin and occupying basolateral ⅔ of tergum; 3rd tergum similar to 2nd, with macula smaller, occupying only basolateral ½, more extensive black pilose on apicomedial ⅔; 4th tergum black except yellow apical margin (incisure), shiny on basal ⅔, dull pollinose apically, black pilose on apical ⅓, elsewhere black pilose medially, yellow pile laterally.

Female.—Similar to male (see Curran's description).

Type data.—*Eristalis semicirculus* Walker, lectotype of unknown sex, in The Natural History Museum, London, labelled "Type" [green circular type label], "Holotype" [red circular type label], "Hond., Dys.," "S. America, Hondura," "Eristalis, semicirculus, Wlk." [in Austen's hand] and "semicirculus" [in Walker's hand]. A mere fragment remains of the type of *E. semicir-*

cula Walker, only the thorax and basal two segments of the abdomen are extant. However, enough remains to be certain of its identity.

Eristalis tenuifrons Curran, holotype ♀ in American Museum of Natural History, New York, labelled "Panama, Canal Zone, Fort Randolph, Feb 6, 1929, C. H. Curran," holotype Eristalis tenuifrons Curran [red type label in Curran's hand].

Material examined.—BELIZE. Stann Creek, Sittes Point, Malaise trap at Possum Point Biological Station, 22–30 April 1987, Spangler & Faitoute (57 ♂ USNM). PANAMA. *Darien*: Garachine, Feb 1953, F.S. Blanton (1 ♂ USNM). *Canal Zone*: Camaron, Fort Kobbe, 22 Jul 1952, F. S. Blanton (1 ♂ USNM).

Distribution.—*Palpada semicircula* is currently known only from Belize and Panama, but probably will be found throughout the lowlands of Central America.

Discussion.—*Palpada semicircula* is a small eristaline fly with the typical *Palpada* appearance of gray pollinose fasciae on the mesonotum and pale maculae on the abdomen. However, the species is immediately separated from almost all other *Palpada* species by the bare katepimeron. *Palpada eristaloides* is the only other *Palpada* species with a bare katepimeron and is distinguished by its larger size and lack of gray fasciae on the mesonotum.

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A NEW CRYPTIC SPECIES OF *TRICHOGRAMMA* (HYMENOPTERA: TRICHOGRAMMATIDAE) FROM THE MOJAVE DESERT OF CALIFORNIA AS DETERMINED BY MORPHOLOGICAL, REPRODUCTIVE AND MOLECULAR DATA

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Abstract.—A new species of *Trichogramma, T. kaykai,* is described from the deserts of southern California where it is a common egg parasitoid of the lycaenid butterfly *Apodemia mormo.* The new species is closely related to *T. deion,* the most common *Trichogramma* in western North America. It is distinguished from *T. deion* by morphological, allozymic and ITS2 sequence differences; the two also appear to be reproductively incompatible.

Key Words: *Trichogramma,* new species, allozymes, ITS2 DNA sequences

Collections of parasitized eggs of the lycaenid butterfly *Apodemia mormo* (C. and R. Felder) on *Eriogonum inflatum* in the Mojave Desert in the spring of 1988 were commonly parasitized by a species of *Trichogramma.* This species was originally considered as a light color form of *T. deion* Pinto and Oatman, the most common *Trichogramma* in western North America (Pinto et al. 1986). This conclusion was questioned when typical *T. deion* was found at the same localities also parasitizing *A. mormo* eggs. Subsequent study showed that this form differed from *T. deion* by minor but consistent morphological traits, and by molecular differences (allozymes and ITS2 sequences). In addition, strains of the two proved to be reproductively incompatible in the laboratory. Because this new species continues to be the subject of various ecological and cytological studies (e.g. Stouthamer and Kazmer 1994) it is important that it receive a formal name. The species description below is followed by a brief summary of crossing results, and allozymic and DNA sequence comparisons. The molecular data are compared among the new species, *T. deion, T. pretiosum* Riley and the Interior form of *T. platneri* Nagarkatti. All taxa are similar morphologically and occur in sympatry in the Mojave Desert.

SPECIES DESCRIPTION

The description is based on an examination of material from all localities comprising the range of the new species. The majority of this material consists of wasps individually mounted on glass slides in Canada balsam. For body length and color several specimens of both sexes [reared at ca. 24° C. and on eggs of *Trichoplusia ni* (Hübner)], and originating from two localities, were critically point dried after being killed in ethanol and mounted on cards. The material of *T. deion* compared in the diagnosis was reared under similar conditions.

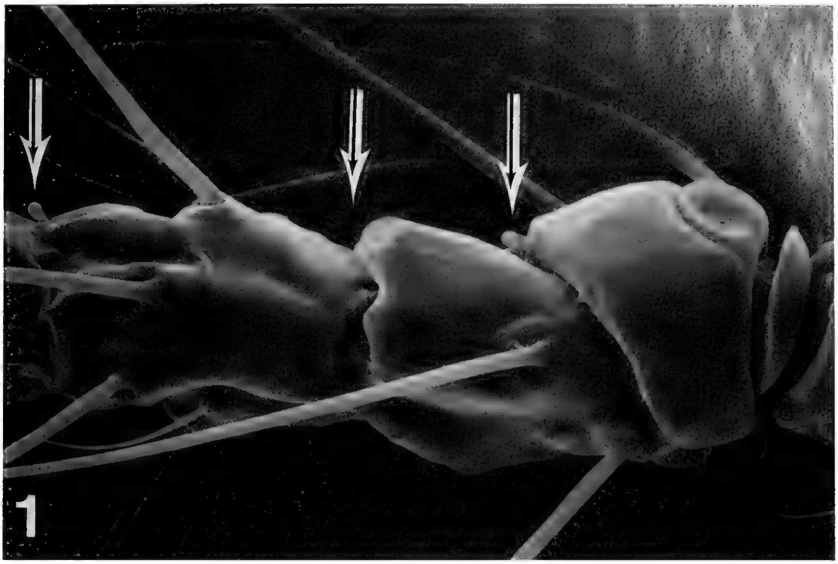


Fig. 1. Antenna of *Trichogramma kaykai* male (ventral of left antenna) showing base of flagellum (1500×). Arrows point to positions 1-3 (from right to left) showing presence of a single basiconic peg sensilla at positions 1 and 3 only. In *T. deion*, all three positions have a single sensilla.

Unless indicated, quantitative data (means ± SD and ranges) are taken from five randomly selected males, all from different localities. The hind tibial length of these specimens ranged from 0.16–0.19 mm. The terminology used in the description follows Pinto (1992).

Trichogramma kaykai Pinto and Stouthamer, new species

Trichogramma sp. near *deion*: Stouthamer and Kazmer, 1994:317.

Trichogramma sp.: Pinto and Stouthamer, 1994:23 (Table 1.1).

Color sexually dimorphic. Male darker with mesosoma including coxae orange brown to yellow brown; pronotum and mesoscutum typically darkest; metasoma primarily light brown; propodeum and posterior part of scutellum typically lightest, yellow orange in color. Female considerably lighter than male. Most of meso- and metasoma uniformly yellow orange; only pronotum, pro- and mesocoxa and ovipositor suffused with brown; anterior 2–3 metasomal terga lightly suffused with brown in some specimens.

Body length 0.4–0.5 mm in males, 0.5–0.6 mm in females.

Forewing 0.28 ± 0.02 mm wide, 0.54 ± 0.01 as wide as long, setation moderately dense with 20–29 setae between 4th and 5th setal tracks, longest fringe setae 0.14-0.20 maximum forewing width. Hind wing with 3–4 and 6–8 setae in anterior and posterior tracks, respectively, the latter attaining 0.5–0.6 the distance from hamuli to apex of wing. Scutellum with anterior pair of setae short, fine, ca. 0.2 the length of posterior pair.

Male.—Antenna with flagellum 0.17 ± 0.01 mm in length, slightly curved, 6.03 ± 0.24 as long as wide, 1.00 ± 0.04 as long as hind tibia, 2.1 ± 0.05 as long as scape; flagellar setae elongate, gradually tapering to apex, the longest of these setae 3.18 ± 0.21 (3.0–3.5) the basal width of flagellum; basiconic peg sensilla (BPS) relatively small, only slightly expanded apically, formula 1-0(1)-1-0-1-1 (i.e. position 2 usually lacking a sensilla as in Fig. 1, also see below for explanation); flagellum lacking unsocketed setae.

Genital capsule (GC) (Figs. 2, 3) moderately broad, 0.34 ± 0.02 as wide as long; sides broadly constricted at level of intervolsellar process (IVP); parameres relatively straight, moderately and evenly convergent to apex; apical distance (between apex of parameres and base of IVP) 0.29 ± 0.01 total GC length; apical width (at base of IVP) 0.63 ± 0.2 greatest width of GC; dorsal aperature (DA) relatively elongate, narrowing considerably posteriorly, its length 0.63 ± 0.03 that of GC; dorsal lamina (DLA) arising slightly anterior to middle of GC, moderately notched at base and narrowing directly posterior to notch forming shoulders which usually do not approach sides of GC; posterior extension of DLA relatively elongate, linguiform, its width at level of IVP subequal to aedeagus width; DLA length from apex of DA = 0.79 ± 0.10 the apical distance and occupying 0.5–0.6 of this distance, usually extending slightly beyond apex of volsellae (VS); VS slightly bowed, occupying 0.4-0.5 the apical distance; IVP narrowly triangular, moderately elongate, occupying 0.3-0.4 the apical distance, its apex usually slightly anterior to that of VS; ventral processes positioned at base of IVP, slightly protuberant; ventral ridge relatively short and indistinct, occupying ca. 0.3 the distance from the base of the IVP to the base of GC. Aedeagus length subequal to that of GC and 0.70 ± 0.03 that of the hind tibia; apodemes consisting of ca. 0.5 entire aedeagus length.

Female.—Antenna with funicle segments subquadrate; usually with 1 BPS on the first funicular segment; second funicular segment usually lacking BPS. Ovipositor subequal in length to hind tibia (see below).

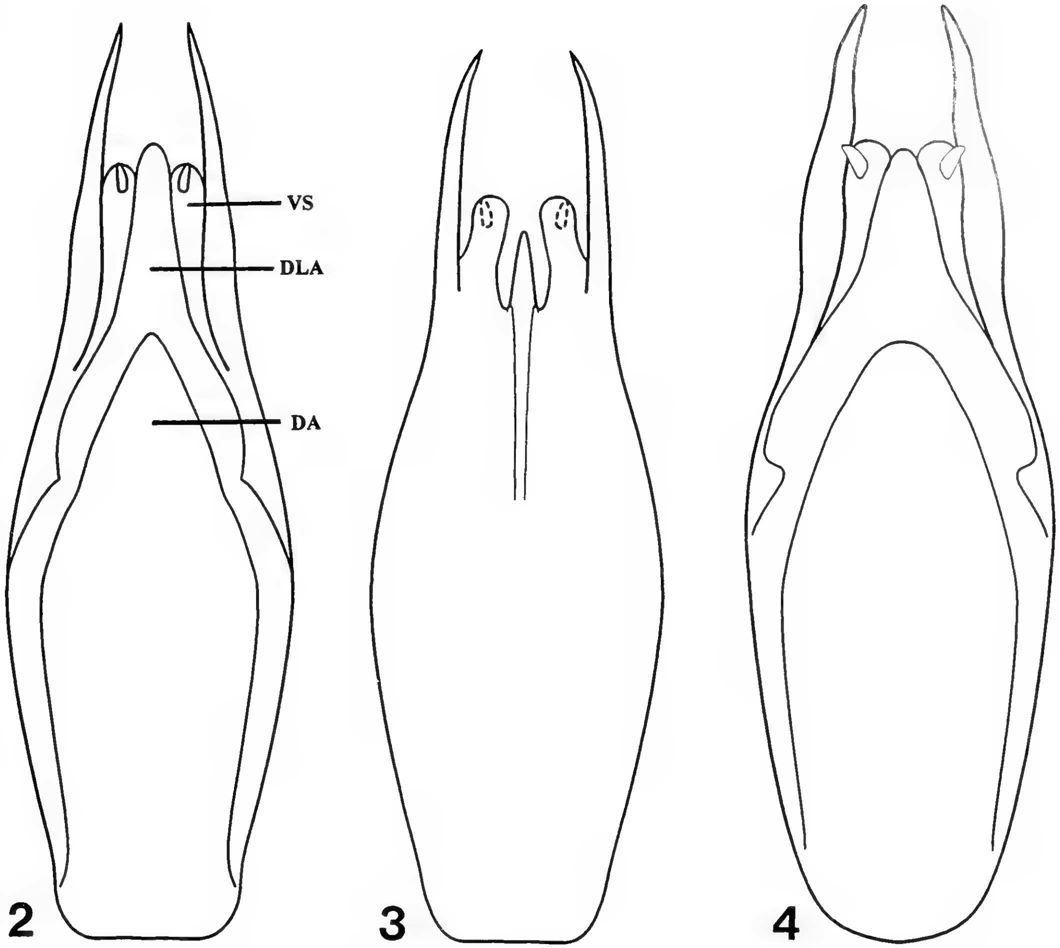
Types.—Holotype ♂ and allotype ♀ from CALIFORNIA, San Bernardino Co., Sheephole Pass, 3 mi. N. on Amboy Rd.; ex. *Apodemia mormo* on *Eriogonum inflatum* Torr. & Frém.; iv-30-93; K. Cooper, J. Pinto & G. Platner, collrs.; in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. Eight ♂ and 3 ♀ paratypes with same data as primary type deposited in collections of the Canadian National Collection, Ottawa; University of California, Riverside; University of California, Berkeley; and The Natural History Museum, London. All type specimens are F1-F7 generation individuals from a culture started with a single female.

Etymology.—The specific name is an arbitrary combination of letters, treated as a noun in the nominative singular and faithful to "KK," the informal epithet applied to this species in our laboratory for several years.

Diagnosis.—*Trichogramma kaykai* is morphologically most similar to *T. deion* and *T. pretiosum.* All three have similar genitalic structure and relatively elongate setae on the male antenna. Males of *T. kaykai* and *T. deion* are separated from *T. pretiosum* by the more distinctly sclerotized posterior extension of the dorsal lamina and the BPS formula on the antenna. Unlike *T. kaykai* and *T. deion, T. pretiosum* has a pair of BPS at the second and third positions. Differences in this trait and male genitalia in *T. deion* and *T. pretiosum* are summarized in Pinto et al. (1986).

Trichogramma kaykai is separated from *T. deion* by color, minor but consistent differences in the male genitalia, BPS formula, and ovipositor length. Color in *T. deion* is not obviously sexually dimorphic as it is in *T. kaykai.* In *T. deion* the mesoscutum and metasoma of both sexes are typically brownish. Males of *T. kaykai* are similar but usually a lighter brown; females, however, are almost uniformly yellow or yellow orange and are easily separated from *T. deion* on this basis.

In most *Trichogramma* there are one or two basiconic peg sensilla (BPS) at each of the first three positions of the male flagellum. The presence of these sensilla are relatively stable within species, although they may be reduced or completely absent at these positions in abnormally small individuals. *T. deion* almost always has a single BPS at the first three positions. In *T. kaykai* a single sensilla is present at positions 1 and 3 but usually not at position 2 (Fig. 1). This



Figs. 2–4. Genital capsule of male (posterior end above). 2, *Trichogramma kaykai* (dorsal view), DLA = dorsal lamina, DA = dorsal aperature, VS = volsella. 3, *T. kaykai* (ventral view). 4, *T. deion* (dorsal view). Note in *T. kaykai* the DA is narrower apically, and the DLA is narrower at its base (immediately posterior to notch) and extends beyond the apex of the VS.

feature is variable, however. Whereas the formula in *T. deion* is relatively stable, about 35% of 135 non-sib males of *T. kaykai* examined had a sensilla at this position. Females of *T. kaykai* can also usually be separated from *T. deion* by the absence of a BPS at the equivalent antennal position, i.e., the apex of the second funicular segment.

Most males of *T. kaykai* can be separated from *T. deion* by genitalia structure (*cf.* Figs. 2, 4). In *T. kaykai* the genital capsule is narrower apically, the dorsal lamina is narrower immediately posterior to its basal notch, and, most importantly, the dorsal aperature is somewhat longer and narrows considerably at its posterior end. Correlated with this difference, the length of the dorsal lamina, measured from the posterior border of the dorsal aperature to its apex, is less in *T. kaykai* and averages 0.79 the apical distance; in *T. deion* this ratio averages 0.93 the apical distance. Also, in *T. kaykai* the lamina typically extends to a level slightly posterior to the apex of the volsellae; it usually does not extend that far in *T. deion.*

Females of *T. kaykai* are most easily distinguished by color. However, the longer ovipositor also helps distinguish it from *T. deion.* Samples of 10 females of each species from localities where the two were sympatric were compared. All originated from different host eggs and had a hind tibial length ranging from 0.19–0.21 mm. In *T. kaykai,* the ratio of ovipositor to hind tibial length was 1.00 ± 0.03; in *T. deion* this ratio was 0.93 ± 0.04. Although the range of variation does overlap, this feature used with the significantly lighter coloration and absence of a BCP on the second funicular segment should provide straightforward separation of females.

Geographic distribution.—*Trichogramma kaykai* has only been collected in southern California -in the Mojave Desert and at the northern limits of the Sonoran Desert.

Hosts.—The primary host of this species is the egg of *Apodemia mormo* (Lycaenidae) laid on *Eriogonum inflatum.* This lycaenid has been divided into several subspecies (Miller and Brown 1981). All records of *T. kaykai* are from *A. m. deserti* Barnes and McDunnough. *Trichogramma kaykai* also has been taken a single time (Pinyon Mt., Kern Co.) on the egg of another lycaenid, *Icaricia lupini* (Boisduval), on *Eriogonum fasciculatum* Bentham.

Material examined.—401 specimens of both sexes. The material examined includes specimens emerging from field collected host eggs and from cultures initiated with these parentals.

Records.—Except for the single record from Pinyon Mt. (see Hosts), all following collections originated from the eggs of *Apodemia mormo* on *Eriogonum inflatum.* UNITED STATES. **California**. *Kern Co.* El Paso Mts. (Bickel Camp); vii-29-96; R. Stouthamer. Pinyon Mt.; vi-4-87; G. Pratt. Walker Pass, 2 mi. E.; iv-19-89; G. Pratt. Last Chance Cyn.; v-14-88; D. Kazmer, R. Stouthamer; also numerous collections by several collectors from iv-vi-95/96. Randsburg; v-14-88; D. Kazmer, R. Stouthamer. *Riverside Co.* Dillon Rd., several collections between immediately east of Indio and Fun Valley (all thelytokous); iv-26-95; J. Pinto, R. Stouthamer. *San Bernardino Co.* Barstow, ca. 10 mi. NE., and ca. 8 mi. E.; v-29-96, v-15-96; L. Bolijn, B. Deijkers. Beacon Station; vi-6-96; L. Bolijn, B. Deijkers. Danby; iv-11-88, iv-30-88, iv-27-95; G. Pratt/D. Kazmer/R. Stouthamer. Joshua Tree; vi-15-96; L. Bolijn, B. Deijkers. Hwy. 66 between Bagdad and Siberia; iv-27-95; R. Stouthamer. Interstate 15, between Victorville and Barstow; v-29-96; L. Bolijn, B. Deijkers. Kramer Hills; v-14-88, iv-24-95; D. Kazmer, R. Stouthamer/J. Bennett, R. Stouthamer. Lucerne Valley, ca. 12 mi. N.; v-29-96; L. Bolijn, B. Deijkers. Sheephole Pass area; v-14-88, iv-27-95; D. Kazmer, R. Stouthamer. Sheephole Pass, 3 mi. N. (on Amboy Rd.) (type locality); iv-30-93; K. Cooper, J. Pinto, G. Platner. Yucca Valley; vi-1-96; L. Bolijn, B. Deijkers.

Notes.—Both thelytokous and arrhenotokous populations of *T. kaykai* have been collected. As in many species of *Trichogramma,* thelytoky in this species is caused by *Wolbachia* infection and can be cured with antibiotic treatment (Stouthamer et al. 1990). Populations with both modes of reproduction occur together in the Mojave Desert. The few collections from the Sonoran Desert are all thelytokous.

Unlike *T. deion* which has very broad host and geographic ranges in western North America (Pinto et al. 1986), *T. kaykai* has been retrieved almost totally from eggs of *Apodemia mormo* in the deserts of southern California. Both species are known to occur together on *Apodemia* at several localities, although *T. kaykai* is more common and appears to be the dominant egg parasite of this butterfly in the Mojave Desert. Of a sample of 256 parasitized *A. mormo* eggs collected at several sites of sympatry during the spring of 1995, 212 or 82.9% were attacked by *T. kaykai*; only 38 or 14.8% were parasitized by *T. deion.* The remainder (2.3%) were attacked by a third and undescribed species. In a few cases, *T. deion* and *T. kaykai* emerged from the same egg.

The eggs of *A. mormo* are relatively large and several *Trichogramma* typically emerge from a single egg. In a sample of 33 eggs collected in 1988 from several localities the average number of *T. kaykai* emerging from each was 4.6 ± 1.2 (range = 1–7). Most of the progeny were female; most parasitized eggs result in a single male and 3–4 females. The average number of males emerging from this sample (excluding eggs resulting in thelytokous wasps) was 1.19 ± 0.75 (range = 0–3, n = 31).

Collections of other species of host at sites where *T. kaykai* occurs are minimal. The only such collection was made on 14 May 1988 at Last Chance Canyon in Kern County. The eight parasitized eggs of *A. mormo* collected on *Eriogonum inflatum* were attacked by both *T. deion* (5) and *T. kaykai* (3). However, only *T. deion* emerged from 23 parasitized eggs of an undetermined Pieridae collected from a species of *Stanleya* (Brassicaceae).

MOLECULAR DATA

Allozymes

An earlier paper compared allozymes in *T. pretiosum* and *T. deion* (Pinto et al. 1993) and reported consistent allelic differences between these close relatives. For this study we examined ten loci in four cultures of *T. kaykai,* and compared them with one culture of the interior form of *T. platneri* Nagarkatti, two cultures of *T. pretiosum* and seven of *T. deion.* All exemplars were run concurrently. The cultures chosen of the latter three species represented most of the known allelic diversity in *Trichogramma* at the loci examined. The enzyme systems used are as follows: Aconitase (4.2.1.3), *Acon*; acid phosphatase (3.1.3.2), *Acp-II*; fumarase (4.2.1.2), *Fum*; *a*-glycerolphosphate dehydrogenase (1.1.1.8), *aGpd-II*; glucose-phosphate isomerase (5.3.1.9), *Gpi*; glucose-6-phosphate dehydrogenase (1.1.1.49), *G6pd*; isocitrate dehydrogenase (1.1.1.42), *Idh*; malate dehydrogenase (1.1.1.37), *Mdh-II*; malic enzyme (1.1.1.40), *Me*; and phosphoglucomutase (2.7.5.1), *Pgm.* These loci, among others, were also compared between *T. pretiosum* and *T. deion* in our earlier study.

The four *T. kaykai* cultures examined were from Walker Pass (KWPA), Last Chance Cyn. (KLC187), and between Bagdad and Siberia (KRB85), three Mojave Desert localities, and Dillon Rd. (N. of Indio) (KAW73), a Sonoran Desert site. The cultures of *T. deion* examined represent much of the range of the species in western North America. The origin of the comparison cultures were as follows: *T. pretiosum* — *R*iverside, CA (PRV4) and Wyndham, Australia (PAWD). Interior form of *T. platneri*—Mesquite, NV (IMSQ). *T. deion* — Riverside, CA (DRV4); Seven Pines, CA (DSVP); Covelo, CA (DCLO); Portal, AZ (DPTL); Granite Gap (Hidalgo Co.), NM (DGGP); Miles City, MT (DMCT); Paul's Place (Kern Co.), CA (DPPL); and Last Chance Cyn (DLC1). All but two of these comparison cultures (DPPL and DLC1) also were examined in our previous paper (Pinto et al. 1993). The culture IMSQ was originally assigned to the interior form of *T. platneri* (Pinto et al. 1992). This form represents a new species and will be described in the near future. Until then we continue to refer to it as before.

All cultures compared represented isofemale lines. One culture of *T. kaykai* (KAW73) was originally thelytokous; all others were arrhenotokous. In the latter case, the female used to initiate a culture had mated with a brother.

Electrophoretic analysis followed methods in our earlier studies (Pinto et al. 1992, 1993) and were originally detailed by Kazmer (1991). Briefly, two females per culture were individually analyzed at each locus by isoelectric focusing in one to two layers of cellulose acetate membranes using a single blend of carrier ampholytes (8% pH 4–6.5 and 2% pH 3–10 pharmalytes) (Sigma Chemical, St. Louis, MO) and an effective gel length of 4.5 cm. Each culture represented an isofemale line initiated from a

Table 1. Allelic comparison of *Trichogramma kaykai* with closely related species at eight loci.[a,b]

		Loci and Alleles							
Taxon	Culture[c]	*AcpII*	*Fum*	*Gpi*	*aGpdII*	*G6pd*	*Idh*	*MdhII*	*Pgm*
Interior form	IMSQ	D	C	B	A	A	A	C	E
pretiosum	PRV4	D	B	B	A	B	B	A	D
	PAWD	D	B	B	A	B	B	E	E
deion	DRV4	C	B	B	B	A	A	C	B
	DSVP	D	B	A	A	A	B	C	C
	DCLO	C	B	B	A	A	B	C	B
	DPTL	D	B	B	A	A	A	B	C
	DGGP	D	B	B	A	A	B	C	B/C
	DMCT	D	B	B	B	A	A	C	A
	DPPL	C	B	B	A	A	B	C	B
	DLC1[d]	—	—	B	—	A	—	C	—
kaykai	KWPA	E	B	C	A	C/F	B	A	B
	KRB85	D	B	C	A	D/E	B	A	B
	KLC187	D	C	D	A	D/E	B	A	B
	KAW73	D	B	C	A	C/E	B	A	B

[a] Relative distances among electromorphs for the three loci distinguishing *T. kaykai* [distances for others given in Pinto et al. 1993)], based on ratio of distance between cathode and homomeric band to entire gel length, as follows (alleles in alphabetical order): *Gpi* (0.18, 0.46, 0.62, 0.67), *G6pd* (0.03, 0.11, 0.19, 0.23, 0.27, 0.32), *MdhII* (0.31, 0.38, 0.47, 0.56).

[b] All females examined were homozygous at all loci. Those entries showing two alleles indicate the two females examined were homozygous for different alleles.

[c] See text for geographic origin of cultures.

[d] DLC1, a *T. deion* collection sympatric with the *T. kaykai* KLC187, was only examined at the three loci distinguishing the two species.

single parasitized host egg collected in the field and maintained in the laboratory for several generations on eggs of *Trichoplusia ni.* BIOSYS-1 (Swofford and Selander 1989, release 1.7) was used to analyze data using individual genotypes as input.

Results.—Two loci (*Acon* and *Me*) were fixed in all samples examined. The remaining eight were polymorphic and are compared for all cultures in Table 1. The four *T. kaykai* cultures differed from all heterospecifics at two loci, *Gpi* and *G6pd.* One of these loci, *G6pd,* is the only one providing complete separation of *T. deion* and *T. pretiosum* (Pinto et al. 1993). The three allozymic differences between *T. kaykai* and *T. deion* also were found in one pair of sympatric collections (from Last Chance Cyn., Kern Co., CA). Cluster analysis based on the data in Table 1, using UPGMA clustering of Nei genetic distances, recognized three groups, all consistent with species identity. IMSQ joined closest to the *pretiosum* cultures. Mean Nei genetic distances between *T. kaykai* and *T. deion,* and between *T. kaykai* and *T. pretiosum* were 0.697 ± 0.24 (0.379–1.178, n = 27) and 0.490 ± 0.13 (0.311–0.668, n = 8), respectively. The mean intraspecific distance for *T. kaykai* was 0.218 ± 0.14 (0.027–0.460, n = 6). The interspecific distances are considerably greater than those reported in our earlier studies of closely related *Trichogramma* and are certainly exaggerated. This is because cultures of both *T. deion* and *T. pretiosum* were chosen for allelic diversity to insure detection of any differences that occurred in the new species.

The presence of at least two alleles of *G6pd* in the cultures of *T. kaykai* (Table 1) requires further investigation. Although this could be explained if the female initiating each culture was heterozygous, it is also possible, and perhaps more likely, that two loci for this enzyme are involved.

Table 2. The size of the ITS2 gene and size of the restriction fragments generated by restriction enzymes MSE1 and ECOR1.

Taxon	Culture[a]	Size ITS2 (bp)	MSE1 restr. fragments (bp)	ECOR1 restr. fragment (bp)
T. deion	DSVP	398	294, 61, 43	398
	DCLO	402	296, 63, 43	402
	DLC1	406	300, 65, 41	406
T. kaykai	KLC187	470	271, 199	470
	KSH1	463	263, 200	463
T. pretiosum	PRV4	409	409	409
	PIRV	413	413	413
Interior form	IMSQ	515	409, 81, 25	325, 190

[a] See text for geographic origin of cultures.

ITS2 DNA Sequences

The ribosomal nuclear genes (rRNA) are among the several genetic sequences proposed for distinguishing closely related species in insects (Hoy 1994). The ITS2 sequence, or Internal Transcribed Spacer region, is positioned between the 5.8S and 28S coding region of the rRNA gene. This sequence shows considerable promise in separating closely related species of *Trichogramma* (van Kan, et al. 1996). In this study we compared the complete ITS2 sequences of two *T. kaykai* cultures, three *T. deion* and two *T. pretiosum* cultures, and one culture of the interior race of *T. platneri* (see Table 2). Each culture represented an isofemale line initiated with a single parasitized host egg collected in the field and maintained for a variable number of generations on eggs of either *Trichoplusia ni, Mamestra brassicae* L. or *Ephestia kuehniella* (Zeller). Differences in sequence and size of the ITS2 gene were determined. Restriction enzymes were used to find characteristic differences among species. Cultures studied are indicated in Table 2. Several of these were also used for allozymes (Table 1). Those examined for ITS2 only include the following: *T. kaykai*—Last Chance Cyn., CA (KLC187); Sheephole Pass area (San Bernardino Co.) (KSH1). *T. pretiosum*—Irvine, CA (PIRV). Cultures included both allopatric and sympatric (DLC1 & KLC187) representatives of *T. deion* and *T. kaykai.*

The method for determining the ITS2 sequence, briefly, is as follows: One to three wasps, preserved in absolute ethanol, were ground in 50–150 μl 5% Chelex and 3 ul proteinase K (20 mg/ml) and incubated for at least 2 hrs. at 56°C followed by 10 min at 95°C. The wasps were first shaken in 1 ml TAE for 1 hr prior to grinding in Chelex. PCR was performed in 50 μl reaction volumes using a Hybaid thermocycler, 5 μl DNA template, 5 μl PCR-buffer, 1 μl dNTP’s (each in a 10mM concentration), 0.6 μl forward and reverse primer (10ng), 0.1 μl SuperTth polymerase enzyme (5 units/ul) from Spaero-Q; and 38 μl sterile distilled water. The ITS-2 region was amplified using the following primers; forward: 5’-TGTGAACTGCAGGACACATG-3’; reverse: 5’-AATGCTTAAATTTAGGGGGTA-3’. The PCR cycling program was 3 min. 95°C, 45 sec. at 53°C and 45 sec. at 72°C with 3 min. at 72°C after the last cycle. The machine was set to tube control. PCR products of about 550 bp were electrophoresed and excised from the agarose gel. They were then frozen and freeze-squeezed. The liquid phase was alcohol precipitated, washed and ligated into a T-tailed vector (Amersham Life Science) and amplified in *E. coli* cells. *Escherichia coli* colonies containing an insert of the correct size were checked by PCR using the primers mentioned above and were subsequently sequenced using an automatic sequencer (373 DNA Sequencer Stretch, Applied Biosystems using a Prism Ready Reaction DyeDeoxyô Terminator Cycle sequence kit). The size of digestion products of the ITS2 gene using different restriction enzymes was determined. Characteristic differences among the species were found using ECOR1 and MSE1.

Results.—The sequences of the ITS2 genes have been deposited in the EMBL, GenBank and DDBJ Nucleotide Sequence Databases. Accession numbers for the species and cultures indicated in Table 2 are as follows: *T. deion*—U76223 (DCLO), U76224 (DLC1), U76225 (DSVP); *T. pretiosum*—U76226 (PRV4), U76227 (PIRV); *T. kaykai*—U76228 (KSH1), U76229 (KLC1); Interior form of *T. platneri*—U76230 (IMSQ).

The size of the *T. kaykai* ITS2 gene is consistently larger than that of either *T. deion* and *T. pretiosum*. The size of the ITS2 gene in order from large to small is: Interior form of *T. platneri* > *T. kaykai* > (*T. deion, T. pretiosum*). The consistent and characteristic differences found in the ITS2 sequences in these four species are reflected in differences in restriction length fragments when the ITS2 gene is restricted with the enzymes MSE1 and ECOR1 as shown in Table 2. The interior form of *T. platneri* differs from the other species in the size of its ITS2 gene (515 bp) and in the presence of the restriction site for ECOR1. *Trichogramma kaykai* differs from both *T. deion* and *T. pretiosum* in the size of its ITS2 gene (470 bp vs 400–410 bp). Also, the ITS2 gene of *T. kaykai* is cut in two large fragments by MSE1 (270 and 200 bp) whereas *T. deion* is cut into three fragments with the largest ca. 300 bp; *T. pretiosum* is not restricted by this enzyme. As with allozymes, the differences between *T. deion* and *T. kaykai* occur in both allopatric and sympatric collections.

REPRODUCTIVE DATA

Reproductive compatibility has frequently been used to support species hypotheses in *Trichogramma* (Pinto and Stouthamer 1994). In this study, four cultures of *T. kaykai* were crossed (at 25°C) with a culture of *T. deion* from Dillon Rd., near Indio, CA (DAW6) and among themselves. The *T. kaykai* cultures used included two from Danby, CA (KDA22, KDA23), and two from Last Chance Cyn., CA (KLC18, KLC21). Crossing procedures employed closely followed those detailed in Pinto et al. (1991). All crosses are based on individual pairings. All combinations of heterogamic crosses were performed concurrently with homogamic controls, resulting in a total of 20 crosses. All crosses included 20 replicates in each direction. For determining relative compatibility between cultures the mean sex ratio (MSR) was calculated as the percentage of female progeny. The relative compatibility of an interculture cross (A × B) is expressed as two percentages: 100% × MSR (A female × B male)/MSR (A female × A male); and the same based on the reciprocal.

Results.—The crosses between cultures of *T. kaykai* and *T. deion* were completely incompatible. Female production is the evidence for reproductive compatibility in arrhenotokous Hymenoptera and not a single female was produced in any of the four heterospecific trials. The mean relative compatibility among the 12 homospecific crosses of *T. kaykai* cultures was 78.0 and ranged from 49.0 to 97.5. The least compatible cross (49.0) was between KDA22 females and KLC21 males. The reciprocal cross was considerably stronger (83.1). There was no evidence that the sympatric cultures (mean compatibility = 74.2, n = 4) were more compatible than the allopatriates (mean compatibility = 79.8, n = 8). In fact, the highest levels (92.6, 97.5) were among allopatric cultures.

CONCLUDING REMARKS

Morphologically similar species of *Trichogramma* as exemplified by *T. kaykai* and *T. deion* are apparently quite common (Pinto and Stouthamer 1994). Yet, we feel that in this genus such cryptic species should be described only after putative morphological differences are shown to be geographically stable and, ideally, found to correlate with other character sources. This requires extensive collecting of all forms involved and an attempt to delineate at least rough geographic distributions. One goal of such work should be the identification of areas of sympatry since it is at such localities that the stability of character differences can be most rigorously tested for. In the case of *T. kaykai,* we have shown that this species has only minor morphological differences from *T. deion* but that these are consistent at several localities including those where the two occur together. Differences in allozymes and the ITS2 sequence, as well as crossing incompatibility, give greater confidence that species recognition is warranted. Thus far we have no evidence of gene flow between these two species. However, a focus of future work should include additional crossing and molecular studies in zones of sympatry. Our efforts in both areas are preliminary.

ACKNOWLEDGMENTS

We thank Gordon Pratt, University of California, Riverside, for his contribution to this study. He was the first to collect the new species and also provided valuable information on its host, *A. mormo.* We also thank F. J. P. M. van Kan for determining the ITS2 sequences reported in this study, and L. Bolijn and B. Deijkers for several of the collections made in the Mojave Desert in the spring of 1996.

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A NEW SPECIES OF *TRYPANARESTA* HERING (DIPTERA: TEPHRITIDAE) FROM PATAGONIA, A POTENTIAL AGENT FOR BIOLOGICAL CONTROL OF SNAKEWEEDS (*GUTIERREZIA* SPP.) IN THE UNITED STATES

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Abstract.—***Trypanaresta valdesiana*, n. sp.,** is described. Illustrations of the egg, third instar larvae, puparia and adults are provided. Larvae develop inside the buds of *Gutierrezia solbrigii* Cabrera and *Gutierrezia mandonii* (Schultz Bipontinus) Solbrig in Patagonia, Argentina. No seeds are produced by infested capitula. Larvae overwinter inside the dry infested buds and adults emerge in spring. Two Hymenoptera, *Torymoides sulcius* (Walker) (Torymidae) and *Epicatolaccus strobeliae* Blanchard (Pteromalidae) are endoparasitoids of larvae and pupae. *Trypanaresta valdesiana* is currently being studied as a potential agent for biocontrol of snakeweeds, *Gutierrezia* spp., in the United States.

Key Words: *Trypanaresta,* Tephritidae, *Gutierrezia,* snakeweed, Asteraceae, weed biocontrol, taxonomy, immature stages

The genus *Gutierrezia* (Asteraceae: Astereae) originated in North America and several species are endemic to the southwestern United States and northern Mexico (Solbrig 1960, Lane 1985). Two perennial species, *G. sarothrae* (Pursh) Britton & Rusby (broom snakeweed) and *G. microcephala* (D.C.) Gray (threadleaf snakeweed), and two annuals, *G. texana* (D.C.) Gray and *G. spharocephala* Gray, are widespread and serious weeds of the semiarid rangelands of the southwestern United States. Twelve species of *Gutierrezia* are endemic to South America, seven from Argentina and five from Chile (Solbrig 1966, Cabrera 1971). All South American species are perennials and have low or no economic impact.

In the U.S.A. losses due to snakeweed have been estimated to be at least $34 million per year (McGinty and Welch 1987, Cordo and DeLoach 1992). Although chemical control is possible, two major problems have almost completely precluded its use: 1) the low economic return of the infested rangelands, and 2) the unpredictability of natural fluctuations in snakeweed populations (DeLoach 1981, Torell et al. 1990). Biological control as an alternative against native weeds using natural enemies of the South American species has been proposed and discussed by DeLoach (1981). Cordo and DeLoach (1992) listed the natural enemies of the Argentine *Gutierrezia* species and discussed climatic and ecological similarities of the troublesome *Gutierrezia* species and the Argentine species.

The purpose of this paper is to describe a new species of *Trypanaresta* that is currently being studied at the South American Biological Control Laboratory, ARS-USDA, Hurlingham, Argentina (SABCL) as a potential agent for the biological control of snakeweeds in the southwestern United States.

MATERIALS AND METHODS

Adults were collected or reared from samples taken in Patagonia, Argentina, from 1993–95. Most of them were reared from mature larvae or pupae in samples of flower heads of *Gutierrezia solbrigii* Cabrera collected near Puerto Pirámide, Chubut province, Argentina. The morphological terminology used for adults follows Foote et al. (1993), for female genitalia Norrbom and Kim (1988), and for larvae Teskey (1981). Measurements were taken from 10 specimens of each sex, as described by Jenkins and Turner (1989). The lengths of syntergosternite 7, eversible membrane, and aculeus were measured ventrally on dissected specimens mounted on a microscope slide (n = 5). Female genitalia were prepared using the technique described in Foote et al. (1993). Larval spiracles and mouthparts were prepared as described by Steck and Wharton (1986).

The following acronyms are used for specimen depositories: MACN, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; SABCL, South American Biological Control Laboratory, Hurlingham, Argentina; USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A. *Gutierrezia* spp. were identified by A. Cabrera of the Instituto Darwinion, San Isidro, Argentina. Parasitoids were identified by L. De Santis (Museo de Ciencias Naturales, La Plata, Argentina). Voucher specimens for plants and parasitoids are deposited at the SABCL.

TAXONOMY

The genus *Trypanaresta* was proposed by Hering (1940) for a group of species similar to *Trupanea* in having a subapical stellate mark in the wing pattern, but with 2 pairs of scutellar setae (the apical at most half as long as the basal), frons setulose, 2–3 frontal and 2 orbital setae. Foote (1967) listed nine species in *Trypanaresta*, but, in addition, all the Neotropical species previously placed in *Goniurella* (Foote 1980) and most South American species previously classified as *Tephritis* (Foote 1967, 1980; Frías 1988) belong in this genus (Norrbom, in prep.). The wing pattern is more extensive in some species than in those originally included by Hering, and the apical scutellar seta is actually minute or absent in a few species, but Norrbom (1993: 205) noted that all species of *Trypanaresta* lack a pair of small but outstanding dorsal preapical setulae on the hind femur. This character diagnoses *Trypanaresta* and the closely related genus *Plaumannimyia* from *Trupanea*, *Euaresta*, and other similar Neotropical genera of Tephritini.

Trypanaresta valdesiana **Gandolfo and Norrbom, new species**

(Figs. 1–3)

Type material.—Holotype: ♂ (MACN) ARGENTINA: Chubut: near Puerto Pirámide, 25-III-1995, Gandolfo & Calcaterra, reared from larva in flower head of *Gutierrezia solbrigii* (197097). Paratypes: same data as holotype, 6 ♂, 5 ♀ (USNM, MACN, SABCL); same except 10-I-1994, D. Gandolfo (153800), 1♀ (USNM); same except 24-I-1994, D. Gandolfo, 1♀ (SABCL); same locality, 9-IX-1994, as overwintering larva in dry capitulum of *Gutierrezia solbrigii,* Gandolfo (174431), 3 ♂, 2 ♀ (SABCL); same locality, 25-I-1994, as larvae in capitula of *Gutierrezia solbrigii,* D. Gandolfo, 1♀ (SABCL); ARGENTINA: Chubut: 11 km. N. Puerto Madryn, 27-III-95, Gandolfo & Calcaterra (197429), 1♀ (SABCL); Puerto Madryn, 27-III-95, Gandolfo & Calcaterra, reared from larva in flower head of *Gutierrezia solbrigii* (197468), 1♀ (USNM); 44 km. SW of Punta Norte, 20-XII-93, D. Gandolfo, reared from capitulum of *Gutierrezia solbrigii* (149792), 1 ♂, 1 ♀ (USNM); Rio Negro:

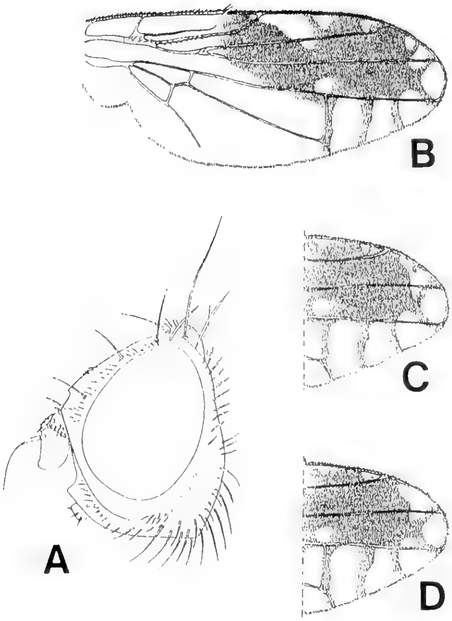

Fig. 1. *Trypanaresta valdesiana* (A) head, lateral view; (B) wing; (C) wing apex with medial ray in cell r_{2+3} incomplete; (D) same, with medial ray absent.

San Antonio Oeste, 8-XII-93, D. Gandolfo, reared from capitula of *Gutierrezia solbrigii* (149010), 1♂ (USNM). Additional specimens examined: 1♀ (SABCL) ARGENTINA, La Pampa, Lihue Calel, 13-I-1995, Gandolfo & Velazquez, reared from capitulum of *G. mandonii* (1785); 2♀ 1♂ (SABCL) ARGENTINA, Río Negro, 17-I-1995, Gandolfo & Velazquez, 4km. W Ramos Mexia, reared from capitula of *G. solbrigii*; 1♀ (SABCL) ARGENTINA, Neuquén, Arroyito 16-I-1996, Gandolfo & Velazquez, reared from larva in flower head of *Gutierrezia solbrigii.*

Diagnosis.—*T. valdesiana* can be distinguished from all other species of *Trypanaresta* by the following combination of characters: apical scutellar seta present; male foreleg unmodified; wing pattern (Fig. 1b) uniformly dark brown; pterostigma connected with r-m by solid dark brown band; discal cell without subapical rays, hyaline except for margin of the broad diagonal band, which extends slightly posterior to vein M between crossveins r-m and dm-cu; and wing basad of pterostigma and at least basal ¾ of cell cu_1 hyaline.

Description.—*Adult*: Body length 3.31-4.13 mm, female barely larger than male. Most setae yellow brown to brown. *Head* (Fig. 1a): barely higher (0.65–0.91 mm) than long (0.48–0.70 mm). Generally yellow, but frons yellow to brown. Frons at vertex wider (0.49–0.72 mm) than long (0.36–0.50 mm), slightly narrowed to anterior margin (0.45–0.65 mm). Anterior half of frons with a few whitish setulae smaller than numerous fronto-orbital setulae (these frontal setulae rub off easily and may not be present in poorly preserved specimens). 2 frontal and 2 orbital setae, posterior orbital smaller, whitish and inflated. Ocellar tubercle blackish, with white setulae. Antenna testaceous-yellow, first flagellomere about as long as wide. Head setae equally long in both sexes. Outer vertical, postocellar and postocular setae whitish. *Thorax*: Ground color of scutum black, of scutellum yellow to pale brown. Mesonotum covered by bright yellow microtrichia except anterior central area of scutum with pale gray microtrichia. Setulae white to yellow, inflated, relatively long (twice as long as in *T. thomsoni*). Scutellum with 2 pairs of setae, apical pair about ⅓ as long as basal. Anepisternal, katepisternal, anepimeral, and posterior notopleural setae white to yellow (concolorous with setulae), other thoracic setae yellow brown to brown. *Wing*: 3.0–3.5 mm long and 1.1–1.6 mm wide. Wing pattern (Fig. 1b) uniformly dark brown. Pterostigma connected to stellate mark by broad, solid band, without hyaline spots; base of band somewhat truncate, not extended to base of R_{4+5} nor with hyaline indentation in cell r_{2+3}. Discal cell totally hyaline except for margin of broad diagonal band, which reaches slightly beyond vein M between crossveins r-m and dm-cu. Dark ray over dm-cu and 2 dark rays crossing cell m all reaching posterior wing margin. Center of stellate mark without hyaline spots; basal ⅔ of cell r_{4+5} dark except for hyaline spot anterior to dm-cu, touching vein M, but never extended to R_{4+5}. Cell r_1 with 3 hyaline marginal marks: the largest, immediately distad of pterostigma, oblique and usually extended beyond R_{2+3}, but never reaching R_{4+5}; one midway between pterostigma and apex of R_{2+3}, triangular and at most extended to R_{2+3}; and a small triangular or quadrate subapical spot often extended to vein R_{2+3}. Cell r_{2+3} usually with 2 small or 1 large marginal hyaline spots, medial dark ray present (Fig. 1b), incomplete or absent (Fig. 1c–d). Basal cells hyaline. Cell cu_1 hyaline except apical margin and sometimes a small subapical brown spot touching Cu_1. *Legs:* yellow. Male fore femur no wider than that of female; in both sexes with posteroventral row of 5 whitish inflated setulae, the basal 2 relatively shorter; also 2 dorsal rows of whitish inflated setulae at most as long as 2 basal of posteroventral row. Male fore tarsus with first tarsomere as long as tarsomeres 2-4 together, without unusual setation. *Abdomen:* In both sexes microtrichia and setulae on abdominal terga concolorous with those on mesonotum. Female: tergite 2 with small setulae on anterior margin, centrally bare and with sparse setulae on posterior half; setulae slightly increasing in density from tergite 2 to 3 and uniformly dense on tergites 4–6. Syntergosternite 7 (Fig. 2a) black, 0.88–0.98 mm long, 0.45–0.53 mm wide at base and 0.12–0.21 mm wide at apex; with evenly distributed white setulae. Eversible membrane 0.8–1.1 mm long, scales as in Fig. 2b. Aculeus pale brown, 0.79–0.88 mm long, in lateral view straight with tip slightly curved downward; tip triangular, with 2 pairs of hairlike sensilla and slightly notched at extreme apex (Fig. 2c). One pair of spermathecae, ovoid, 0.49–0.62 mm long and 0.30–0.32 mm wide, surface with papillae (Fig. 2d). Male: setulae on tergites similar to female in size, density and distribution. Sternite 5 with posterior margin concave (Fig. 2e). Epandrium with setulae and microtrichia distributed as in Fig. 2f–g. Outer surstylus indistinguishably fused to epandrium. Inner surstylus with 2 pairs of prensisetae; lateral prensiseta conical, ca. ⅔ as long as mesal prensiseta; between prensisetae a group of 2–3 setulae and also a group of 3 setulae near base of lateral prensiseta. Basiphallus 0.90–1.10 mm long; internal sclerites of distiphallus 0.20–0.23 mm long, apex of distiphallus membranous, ca. ⅓ length of internal sclerites.

Egg: Ellipsoidal, shiny, white, 1.0 mm long and 0.3 mm wide (n = 10). Chorion with pattern of more or less hexagonal areas, more elongated on anterior end (Fig. 2h). Posterior pole tapered. Anterior pole ends in nipple-shaped pedicel perforated with several aeropyles (Fig. 2i).

Larva: Mature larva (third instar) yellow, globose, 2.65 ± 0.1 mm long and 2.09 ± 0.16 mm wide (±SD, n = 20) (Fig. 3a). The most remarkable character is a posterior area between posterior spiracles and anal slit, which is more sclerotized and pale brown. Sclerotized area on the ventral edge with small indentation enclosing anal slit; laterally some darker marks aligned in two pairs of parallel lines at 30° angle with medial line (Fig. 3b). Thoracic segments without spinules or a few on third segment, abdominal segments with conical spinules more numerous on dorsum; spinules on the dorsum of abdominal segments 7 and 8 more sclerotized, producing distinct dark area. Surface of posterior sclerotized area uniformly covered by conical spinules, rest of caudal segment with spinules as on abdominal segments. Cephalopharyngeal skeleton as in Fig. 3c. Mandible short, with two stout, apically rounded teeth. Labial sclerite well developed. Hypopharyngeal sclerite rectangular, elongate, ca. three times as long as high. Parastomal bars fused to both hypopharyngeal sclerite and tentoropharyngeal sclerite. Pigmented area of dorsal cornu with posterior end bifid, ventral cornu with ovoid window. Anterior spiracle with 3–4 papillae, felt chamber filled with round reticulation (Fig. 3d). Posterior spiracle located above medial horizontal line of caudal segment (Fig. 3b). Dorsal spi-

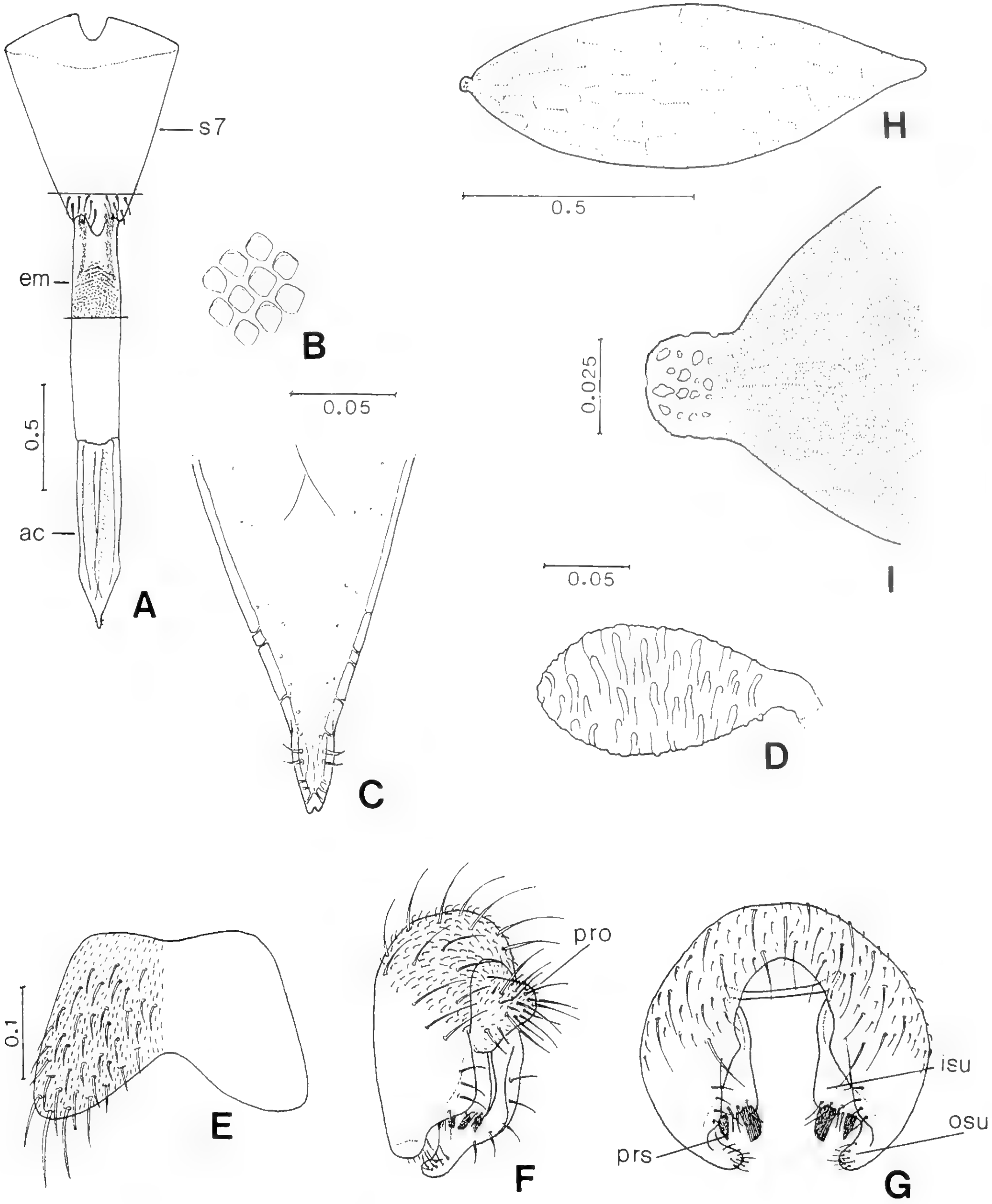

Fig. 2. *Trypanaresta valdesiana*: A-D female (A) female terminalia; (B) scales of the eversible membrane; (C), aculeus tip; (D) spermatheca; E-G male terminalia (E) sternite 5; (F) epandrium and surstyli, lateral view; (G) epandrium and surstyli (proctiger not shown), posterior view ; (H) egg; (I) detail of pedicel. ac, aculeus; em, eversible membrane; isu, inner surstylus; osu, outer surstylus; pro, proctiger; prs, prensisetae; s7, syntergosternite 7.

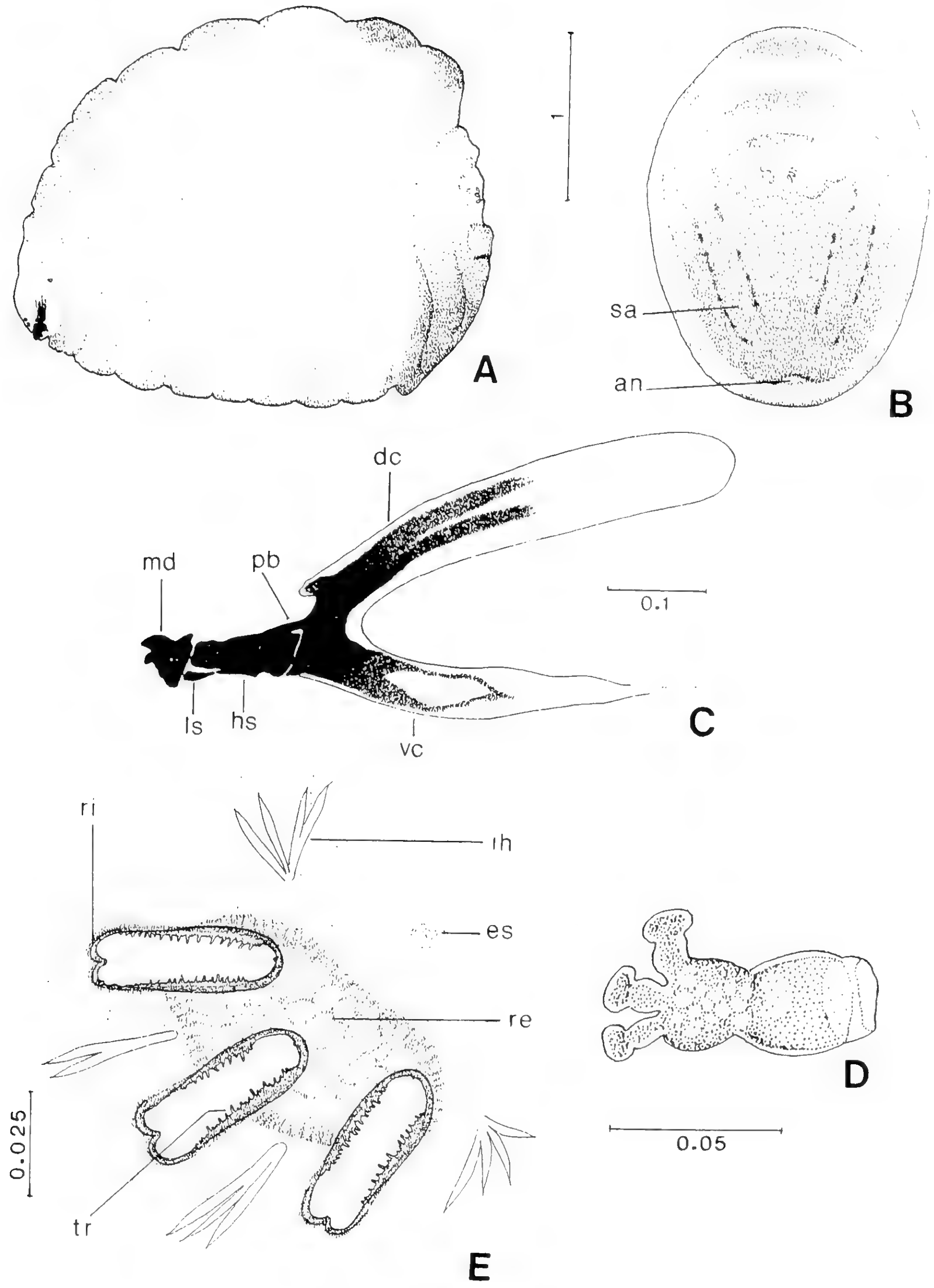

Fig. 3. *Trypanaresta valdesiana,* third instar larva (A) habitus, lateral view; (B) posterior view; (C) cephalopharyngeal skeleton; (D) anterior spiracle; (E) posterior spiracle. sa, sclerotized area; an, annus; dc, dorsal cornu; es, ecdysial scar; hs, hypopharyngeal sclerite; ih, intraspiracular hairs; ls, labial sclerite; md, mandibles; pb, parstomal bar; re, reticulum; ri, rima; tr, trabeculae; vc, ventral cornu.

racular opening at right angle with medial line, and at approximately 60° angle with ventral spiracular opening (Fig. 3e). Upper edge of rimae somewhat twisted, inner edge with short and irregular trabeculae, never forming crossbars; felt chamber with round reticulation. Four groups of branched intraspiracular hairs, each branch blade ending in acute tip, the 2 groups closer to central rima with 1–3 branches, the other 2 groups with 4–6 branches (Fig. 3e).

Puparium: Puparium more cylindrical than larva. Average length 2.8 ± 0.27 mm, maximum width 1.4 ± 0.16 mm (n = 20). The anterior extreme, including invagination scar, dark brown to black, the rest uniformly pale brown or rarely ivory. The sclerotized area described for the larva readily observed in puparium.

Etymology.—The epithet is an adjective that refers to the Valdes peninsula, Chubut province, Argentina, where the larvae were originally collected.

Biology.—At the beginning of spring (September), females presumably lay eggs in immature heads of *G. solbrigii.* The heads attacked by *T. valdesiana* are distinguished as they dry up prematurely and never fully open (Fig. 4). The contents of these "dry heads" are totally consumed and the space is occupied by the larva. The mature larva is inside a cell with rigid walls apparently formed by flower tissues cemented by feces. No achenes are produced in infested capitula. At the end of the blooming season most larvae enter diapause and remain inside the dried flower heads until the next spring when they pupate and adults finally emerge. In the population studied near Puerto Pirámide, about 5–10% of the larvae pupariate near the end of the blooming season (January), and behaves as a bivoltine species. The adults that emerge from those puparia are still able to find some plants with young heads suitable for oviposition.

Natural enemies.—Two species of endoparasitic chalcidoids wasps, *Epicatolaccus strobeliae* Blanchard (Pteromalidae) and *Torymoides sulcius* (Walker) (Torymidae), were reared from larvae and puparia of *T. valdesiana.* The former was known as a parasitoid of the nonfrugivorous tephritid *Strobelia baccharidis* Rondani (Blanchard 1940), and has been reared from immatures of at least six species of florivorous tephritids from Patagonia (Gandolfo, unpublished). *Torymoides sulcius* was known as a parasitoid of gall midges, and occurs from Texas to South America (E.E. Grissell, pers. comm.). In samples of flower heads of *G. solbrigii* that were infested by larvae of *T. valdesiana* and *Trupanea patagonica* (Brèthes), *Torymoides sulcius* was reared exclusively from the former species. Both parasitoids killed, at the end of the 1994–95 growing season, 53% of the larvae and pupae of *T. valdesiana* in a population near Puerto Pirámide (Gandolfo, unpublished). Instead of leaving the bud through the apex, as the flies do, the adult parasitoids make a

Fig. 4. Flower head of *Gutierrezia solbrigii* infested by *Trypanaresta valdesiana.*

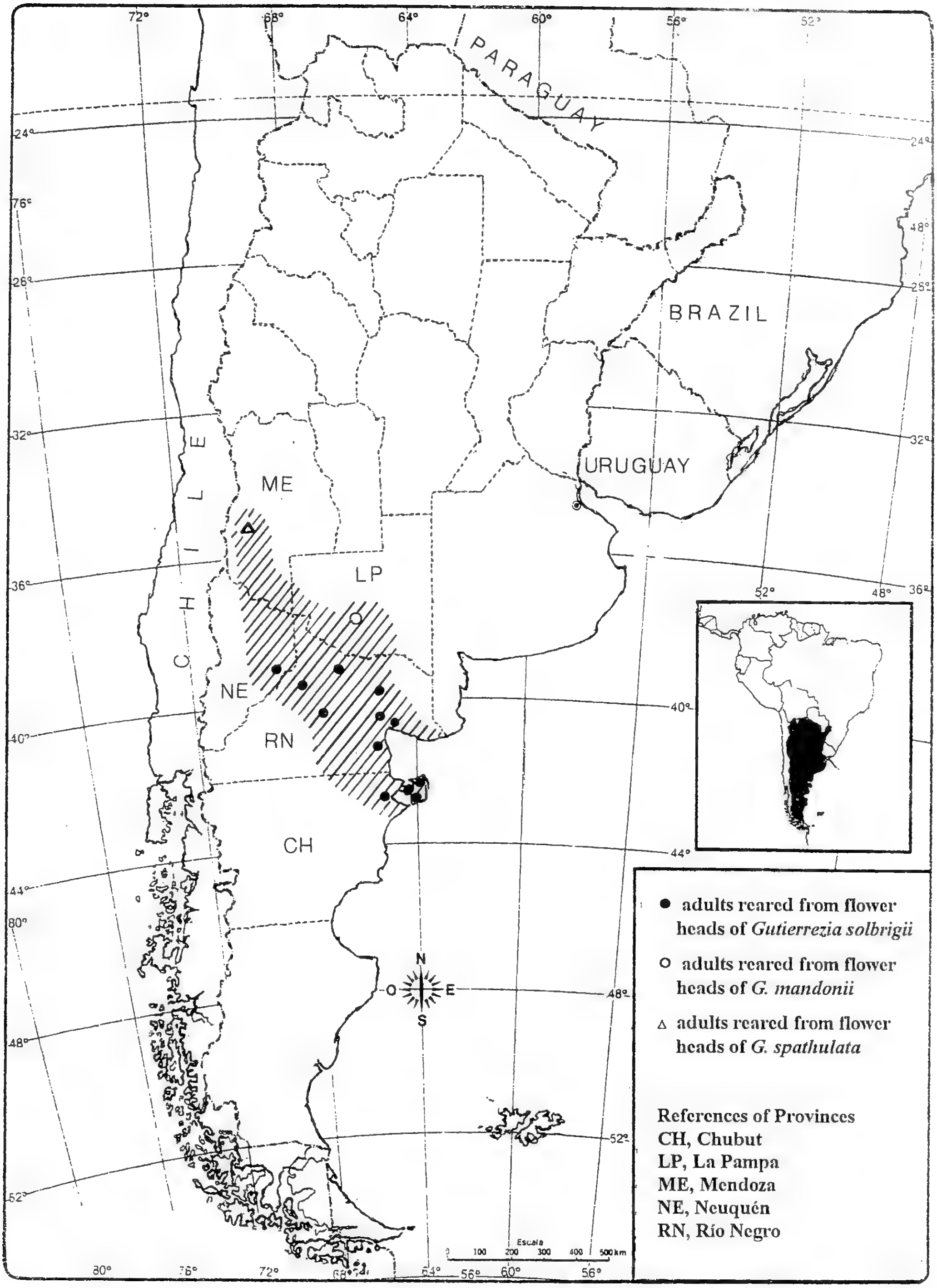

Fig. 5. Geographical distribution of *Trypanaresta valdesiana.*

circular hole on the upper half of the dry bud.

Host plants.—*Gutierrezia solbrigii* Cabrera, *G. mandonii* (Schultz Bipontinus) Solbrig and *G. spathulata* (Phil.) Kurtz.

Geographical distribution.—Argentina: west to east Patagonia between 38° and 43° S (Provinces of Chubut, Río Negro, Neuquen, La Pampa and Mendoza) (Fig. 5).

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REDESCRIPTION OF THE SUBGENUS *HYGIA* (*EUCOLPURA*) BREDDIN (HEMIPTERA: COREIDAE: COLPURINI), WITH THE DESCRIPTION OF TWO NEW SPECIES, AND A KEY TO THE KNOWN SPECIES

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Abstract.—The subgenus *Hygia* (*Eucolpura*) Breddin is redescribed and two new species ***H.* (*E.*) *heveli*** and ***H.* (*E.*) *melas*** from Borneo are described; *H.* (*E.*) *speculatrix* (Breddin) is made a junior synonym of *H.* (*E.*) *lugubris* (Walker); habitus view illustrations and drawings of the male and female genitalia are provided; a key to the known species is included.

Key Words: Insecta, Heteroptera, Coreidae, Colpurini, *Hygia* (*Eucolpura*), new species, Borneo

The genus *Hygia* Uhler (1861) contains ten subgenera, *Australocolpura* Brailovsky, *Caracolpura* Breddin, *Colpura* Bergroth, *Eucolpura* Breddin, *Hygia* Uhler, *Microcolpura* Breddin, *Pterocolpura* Blöte, *Sphinctocolpura* Breddin, *Stenocolpura* Breddin and *Trichocolpura* Breddin, and approximately 79 species, widely distributed in the Oriental Region throughout Japan, China, Taiwan, India, Burma, Assam, Korea, Cambodia, Malacca, Sarawak (Borneo), West Malaysia, Sumatra, Singapore, Java, Philippines, Sulawesi, Mentawei, New Guinea and Australia (Brailovsky 1993)

The present paper adds two new species in *Hygia* (*Eucolpura*) whose members are distinguished by having the genae laterally armed, the pronotum nearly campanuliform, and the humeral angles angulately or nearly prominent.

The following abbreviations are used for the institutions cited in this paper: BMNH (The Natural History Museum, London, England); BPBM (Bernice P. Bishop Museum, Honolulu, Hawaii); DEI (Deutsches Entomologisches Institut, Germany); IRNB (Institut Royal des Sciences Naturelles, Bruxelles, Belgique); NSMT (National Science Museum, Tokyo, Japan); UNAM (Colección Entomológica, Instituto de Biología, Universidad Nacional Autónoma de México); USNM (National Museum of Natural History, Smithsonian Institution, Washington D.C.); ZIL (Zoological Institute, Leningrad); ZMUA (Zoologisches Museum, Universiteit van Amsterdam, Netherlands).

All measurements are given in millimeters.

Hygia (*Eucolpura*) Breddin

Colpura (*Eucolpura*) Breddin, 1900b: 202.
Hygia (*Eucolpura*) Blöte, 1936: 35, 38.

Diagnosis.—The genus *Hygia* Uhler includes ten subgenera (Brailovsky, 1993), two of which, *H.* (*Colpura*) Bergroth and *H.* (*Eucolpura*) Breddin, have the genae projecting into acute or obtuse teeth. In the other subgenera, the genae are, simple without teeth or lateral projections.

Hygia (*Colpura*) includes more robust species, with the sharp teeth of genae clearly projecting laterally and visible from above; the pronotum is trapezoidal with the anterolateral borders straight or nearly so, and the humeral angles are very broadly rounded. In *H.* (*Eucolpura*), the teeth of genae are obtuse, the pronotum is more or less campanuliform, and the humeral angles are angulate and prominent.

Redescription.—*Head:* Wider than long, pentagonal, flat dorsally; tylus unarmed, globose apically, extending anteriorly to jugae, slightly raised in lateral view; jugae unarmed, thickened, shorter than tylus; genae with obtuse teeth directed forward; antenniferous tubercle unarmed; side of head in front of eye unarmed, subparallel; antennal segment I moderately robust, thickest, slightly curved outward and longer than head; segments II and III cylindrical, slender; segment IV fusiform, slender; segment II the longest, segment IV shortest and III subequal to I; antennal segment IV longer than length of head; ocelli well developed, strongly elevated; preocellar pit deep; eyes large, spherical, sessile; postocular tubercle protuberant; buccula rounded, short, not projecting beyond antenniferous tubercle, with sharp spiny anterior projection; rostrum reaching anterior third of abdominal sternite III or anterior third of V; mandibular plate unarmed.

Thorax: Pronotum wider than long, campanuliform, slightly declivent; collar wide; frontal angles rounded or produced forward as small lobe or conical teeth; humeral angles rounded and either not or angulately exposed, prominent and elevated; anterolateral borders with anterior half convex and posterior half oblique, straight; posterolateral borders and posterior border nearly straight; callar region slightly convex, well developed with median longitudinal depression. Anterior lobe of metathoracic peritreme reniform, globose, posterior lobe sharp, small.

Legs: Femora densely granulate, with two rows of spines along ventral surface; tibiae with shallow sulcus, sometimes difficult to see.

Scutellum: Triangular, flat, longer than wide; apex barely globose, subacute or nearly flat and acute.

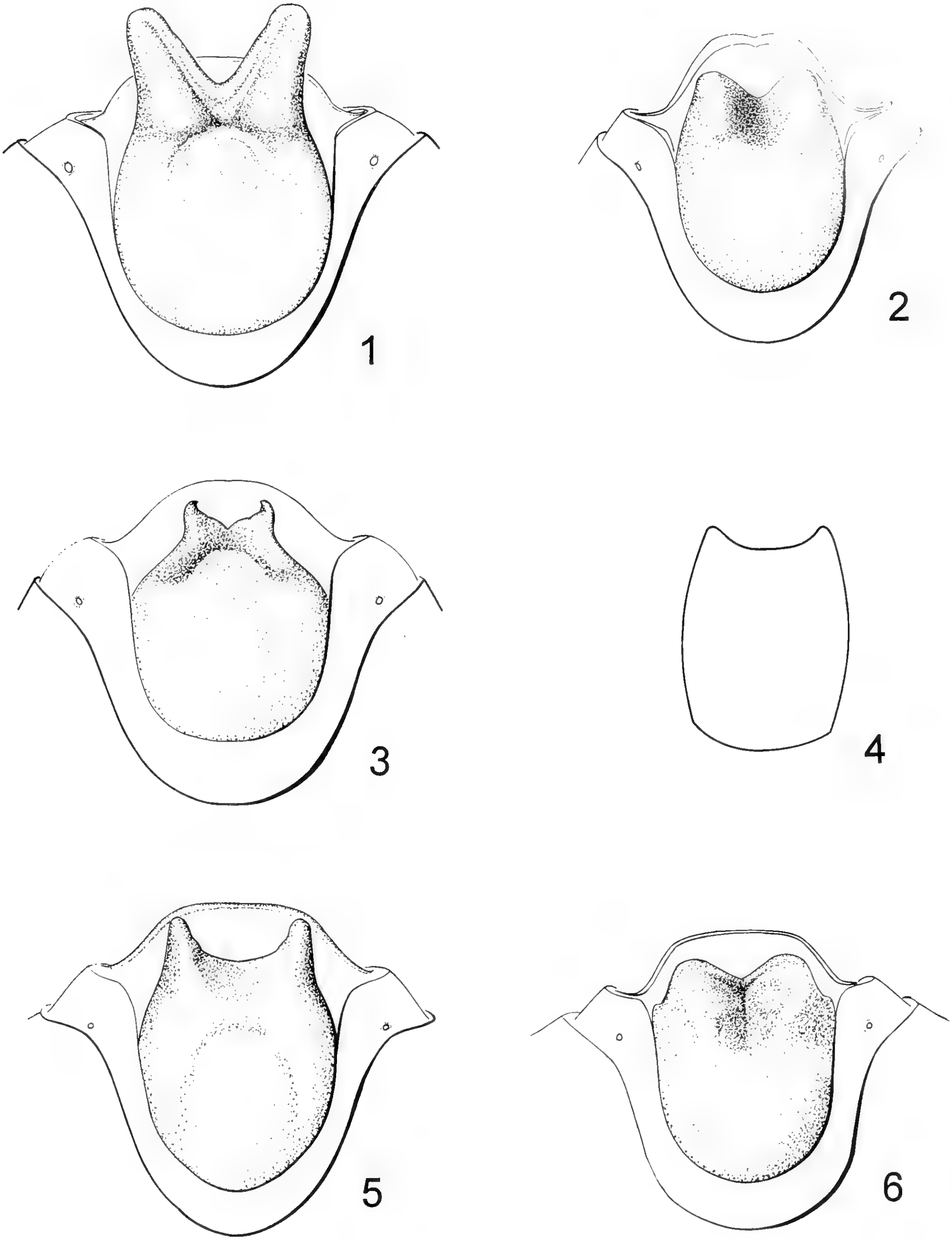
Hemelytra: Macropterous, reaching almost the apex of the last abdominal segment; claval suture evident; apical border oblique, straight, with short apical angle, not reaching middle one third of hemelytral membrane.

Abdomen: Connexival segments higher than abdominal terga: superior border of connexiva serrate; posterior angle of each connexival segment complete, except the VI moderately exposed; abdominal sterna with medial furrow extending to the anterior margin of sternite V.

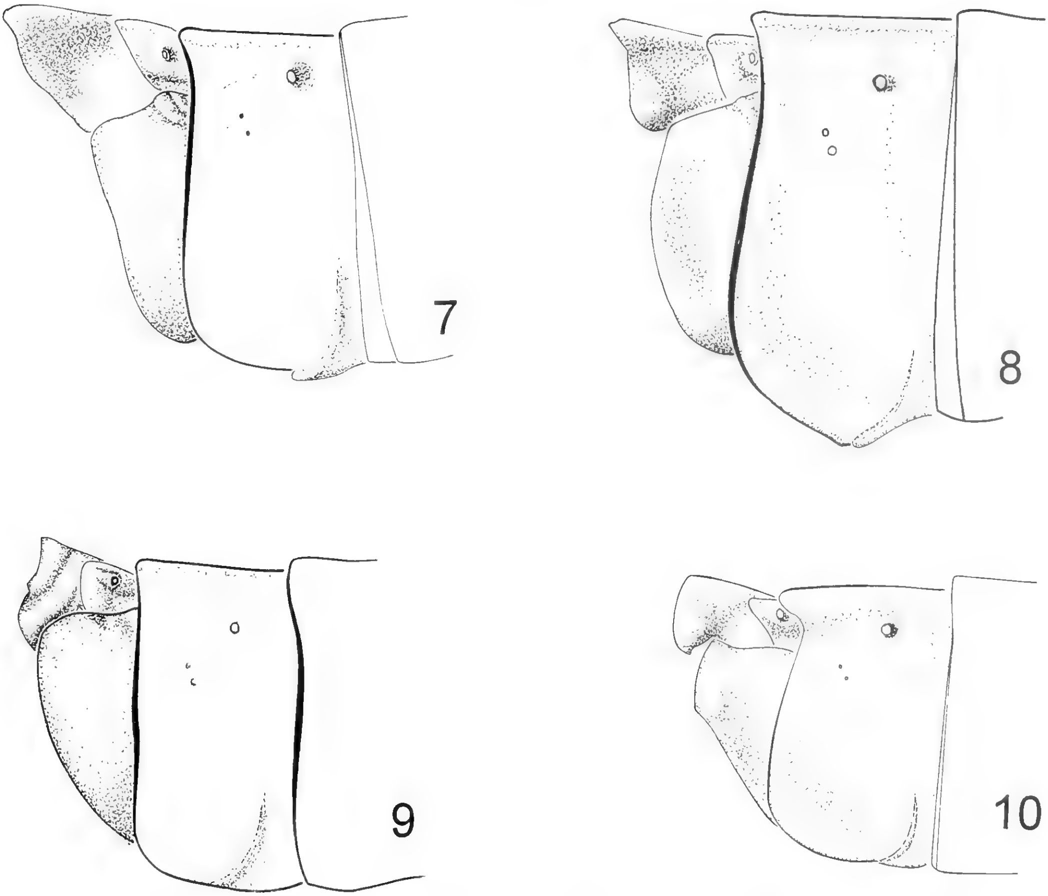
Integument: Body surface rather dull, with mesosternum lateraly shining. Head ventrally, pronotum, scutellum, clavus, corium, thorax, and abdomen densely covered with circular greyish-white farinose punctures, with short decumbent silvery bristle-like setae, intermixed with few long erect hairs located on the abdominal sterna. Head dorsally and callar region scarcely punctate to smooth; male genital capsule and female genital plates densely punctate, with long erect or semierect setae. Pubescence of antennae and femora short, mainly suberect, on tibiae and tarsi longer and rather dense.

Male genitalia: Genital capsule: Posteroventral edge subtruncated, or shallowly emarginated with lateral lobes short and wider (Figs. 2, 6), or short and narrow (Fig. 4), or projected on a medium plate with lateral lobes subacute (Fig. 3) or deeply emarginated, with lateral lobes elongated (Fig. 5) or strongly bilobed with lateral lobes remarkably wider (Fig. 1).

Female genitalia: Abdominal sternite VII with plica and fissura; plica triangular, wide, reaching anterior third (Fig. 10), or almost medial third of sternite VII (Figs. 7–9); gonocoxae I squarish, enlarged dorsoventrally, in lateral view with external face entire, straight, and open ventrally; paratergite VIII quadrate, with spiracle visible;



Figs. 1–6. *Hygia* (*Eucolpura*), male genital capsule in caudal view. 1, *H.* (*E.*) *melas*. 2, *H.* (*E*). *scrutatrix*. 3, *H.* (*E*). *lugubris*. 4, *H.* (*E*). *moesta*. 5, *H.* (*E*). *heveli*. 6, *H.* (*E*). *scrutatrix*.



Figs. 7–10. *Hygia* (*Eucolpura*), female genital capsule in lateral view. 7, *H.* (*E*). *melas.* 8, *H.* (*E*). *heveli.* 9, *H.* (*E*). *scrutatrix.* 10, *H.* (*E*). *lugubris.*

paratergite IX square, medium size, extending beyond the external face of gonocoxae I and with the external margin of various shapes (Figs. 7–10).

Type species.—*Lybas lugubris* Walker, 1871.

Historical notes.—Walker (1871) described *Lybas lugubris* from three different localities Singapore, Sarawak and New Guinea and *Lybas moestus* from Java. The third known species, *Colpura speculatrix* (Breddin 1900a), was described from Borneo and Sumatra. Breddin (1900b) revised the Tribe Colpurini (= Pachycephalini, = Lybantini), included in the genus *Colpura* Bergroth (1894), the new subgenus *Eucolpura,* described the fourth species *C. scrutatrix* from Borneo, and transfered the last three species into *Eucolpura.* Subsequently, Breddin (1906) described *C.* (*E.*) *dolens* from Sumatra and *C.* (*E.*) *severa* from Java and synonymized *C.* (*E.*) *speculatrix* under *C.* (*E.*) *lugubris* and *H.* (*E.*) *severa* under *H.* (*E.*) *moesta.* Blöte (1936) synonymized the genus *Colpura* under *Hygia* Uhler (1861), gave new records for *H.* (*E.*) *lugubris, H.* (*E.*) *moesta, H.* (*E.*) *scrutatrix,* and resurrected *H.* (*E.*) *speculatrix* to species status.

Examination of type material for *H.* (*E.*) *lugubris* (BMNH), *H.* (*E.*) *moesta* (BMNH), *H.* (*E.*) *scrutatrix* (DEI), and *H.* (*E.*) *speculatrix* (DEI), study of undetermined specimens, as well as the original description and drawings of the male genital capsule of *H.* (*E.*) *dolens,* resulted in the recognition of two new species from Borneo and confirmation that *H.* (*E.*) *speculatrix* is a junior synonym of *H.* (*E.*) *lugubris.* On the general pattern of distribution for the subgenus, we believe the New Guinea locality for *H.* (*E.*) *lugubris* is erroneous.

Hygia (*Eucolpura*) *melas* Brailovsky and Barrera, new species

(Figs. 1, 7, 11)

Description.—Measurements: male first, then female: Head length 2.08, 2.32; width across eyes 2.26, 2.36; interocular space 1.12, 1.20; interocellar space 0.52, 0.56; preocular distance 1.36, 1.48; length antennal segments: I, 3.36, 3.40; II, 4.28, 4.36; III, 3.36, 3.48; IV, 2.36, 2.44. Pronotum: Total length 3.32, 3.70; width across frontal angles 1.80, 2.20; width across humeral angles 5.08, 5.76. Scutellar length 2.28, 2.76; width 2.12, 2.56. Total body length 15.36, 18.05.

Male.—Coloration: Head dark red, with dorsal face of postocular tubercle, and anterior third of buccula yellow, with following areas with bright orange reflections: tylus, antenniferous tubercles, and posterior third of buccula; antennal segments I to III bright orange (base of I yellow) and IV pale yellow with basal join and apex pale orange brown; rostral segments I to III pale brown, and IV pale orange yellow with apex pale brown; pronotum pale brown red with callus, and humeral angles dark red to black; scutellum, clavus, corium, connexival segments, thorax, and abdominal sterna pale brown red with following areas yellow: apex of scutellum, clearly discoidal spot located on inner third of apical margin of corium, posterior third of connexival segments III to VII, posterior third of pleural sterna III to VII, and posterior border or posterior margin of abdominal sterna V to VII; anterior and posterior lobe of metathoracic peritreme creamy yellow; hemelytral membrane dirty yellow, with veins and large distal spot brown, with basal angle black; dorsal abdominal segments I to III pale orange yellow, and IV to VII dark red with orange reflections; genital capsule dark red; coxae brown red with pale orange reflections, and with apical third pale yellow; trochanters pale yellow with small bright orange spot located on inner third of apical margin; femora and tibiae with three narrow longitudinal stripes dark brown red, and three narrow stripes pale yellow; tarsi bright orange yellow.

Male.—Structure: Rostrum reaching anterior to middle third of abdominal sternite IV; frontal angles rounded; humeral angles angulately exposed, and moderately prominent. Genital capsule: Posteroventral border strongly bilobed, with lateral lobes remarkably wider (Fig. 1).

Female.—Coloration: Similar to male. Connexival segments VIII and IX, abdominal segments VIII and IX, and genital plates pale to dark brown red, with following areas yellow: posterior third of connexival segment VIII, posterior angle of paratergite VIII, and inner angle of gonocoxae I. Genital plates. Parategite IX square, medium size, extending beyond external face of gonocoxae I, and with external margin entire and not folded (Fig. 7).

Variation.—1, rostral segment IV pale orange; 2, hemelytral membrane yellow with veins brown red, and basal angle black; 3, dorsal abdominal segments I to V or VI bright orange yellow, with punctures darker; 4, scutellum and thorax dark red; 5, femora and tibiae sometimes with dark brown red and yellow stripes difficult to segregate but always present; 6, posterior lobe of metathoracic peritreme dirty yellow.

Type material.—Holotype: ♂, Malaysia, Borneo, Sandakan, Baker (without data) (USNM). Paratypes: 2 ♂, 2 ♀, same data as holotype (USNM, UNAM); 1 ♀, N. Borneo, Kuching, March 1900, Dyak (BMNH); 1 ♀, Sarawak, Baram River, Gunong-Tamabo, 7 November 1920, J.C. Moulton (UNAM); 1 ♂, O. Borneo, Midden, 18 February 1925, H.C. Siebers (ZIL); 1 ♀, Borneo, M.O. Borneo Exp., Long Petak

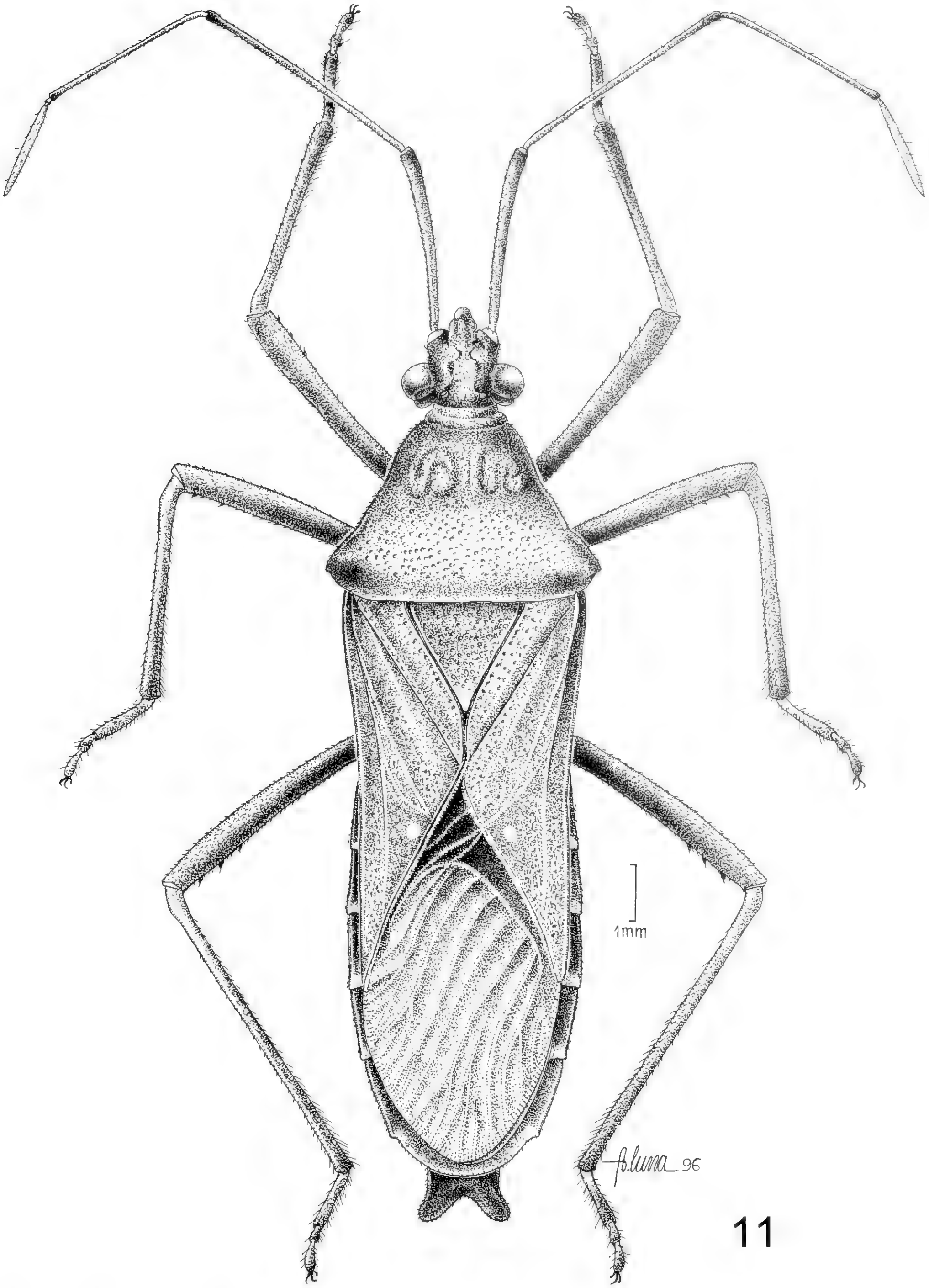


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Fig. 11. Dorsal view of *Hygia* (*Eucolpura*) *melas*, male.

(450 mts.), 24 August to 9 September 1925, H.C. Siebers (ZIL); 1 ♂, Sarawak, Ulu Akar, November 1914, P. de F. (UNAM); 1 ♂, Sarawak, Matang, December 1898 (BMNH); 1 ♂, 2 ♀, Sarawak, Mt. Matang, 21 December 1913, January to February 1914 (BMNH); 2 ♀, Malayan Peninsula, Selangor (2000 mts.), C.B. Klon (without data) (BMNH); 1 ♀, Malayan Peninsula, Bukit Kutu, (3457 ft), 18 September 1930, N.C.E. Miller (UNAM); 1 ♂, Malayan Peninsula, SE. Pahang Rompin Mining, 32–37 km., from Petoh, 24 January 1961, T.C. Maa (BPBM); 1 ♂, Malayan Peninsula, Selangor, Gombak Valley, 20 October 1921, H.M. Pendlebury (UNAM); 1 ♂, Malayan Peninsula, Pahang (without data) (IRNB).

Notes.—*Hygia* (*E.*) *melas* is easily distinguished by the strongly bilobed shape of the posteroventral border of the male genital capsule, which is lateraly delimited by two remarkably pronounced arms (Fig. 1) and by having the external margin of the paratergite IX entire and not folded (Fig. 7). An additional condition is the peculiar coloration pattern of the femora, with three dark brown, narrow, longitudinal stripes and three pale yellow stripes.

Etymology.—From the Greek melas, meaning black, and refering to the black coloration of the humeral angles.

Distribution.—Known from the type localities.

Hygia (*Eucolpura*) *heveli* Brailovsky and Barrera, new species
(Figs. 5, 8, 12)

Description.—Measurements: male first, then female: Head length 2.24, 2.48; width across eyes 2.32, 2.52; interocular space 1.16, 1.32; interocellar space 0.52, 0.59; preocular distance 1.38, 1.57; length antennal segments: I, 3.92, 4.04; II, 5.04, 5.04; III, 4.00, 3.88; IV, 2.72, 2.72. Pronotum: Total length 3.04, 3.56; width across frontal angles 1.72, 2.23; width across humeral angles 4.52, 5.50. Scutellar length 2.28, 2.60; width 1.76, 2.28. Total body length 15.69, 18.28.

Male.—Coloration: Head dark red with dorsal face of postocular tubercle, and anterior third of buccula yellow, with following areas with bright orange reflections: apex of tylus, antenniferous tubercle, and buccula; antennal segments I to III bright orange, and IV pale yellow with basal join bright orange; rostral segments I to III bright chestnut orange, and IV bright orange, with apical third darker; pronotum with collar, anterior lobe, and humeral angles black, and posterior lobe reddish brown; scutellum dark reddish brown, with apex pale yellow; clavus and corium pale reddish brown with yellow discoidal spot located on the inner third of apical margin of corium; hemelytral membrane dirty yellow, with basal angle black, and apical third with large brown blotch; connexival segments pale reddish brown, with posterior third yellow; abdominal segments I to V pale orange red, and VI to VII dark red; thorax dark reddish brown, with acetabulae bright chestnut orange; anterior and posterior lobe of metathoracic peritreme creamy yellow; abdominal sterna dark reddish brown with following areas yellow: posterior third of pleural sterna III to VII, and posterior border of abdominal sterna V to VII; genital capsule dark to pale reddish brown, with lateral lobes bright orange; coxae and trochanter bright yellow; femora with two longitudinal stripes yellow and two bright orange; tibiae and tarsi bright orange.

Male.—Structure: Rostrum reaching middle third of abdominal sternite IV or anterior third of V; frontal angles rounded; humeral angles angulately exposed, and moderately prominent. Genital capsule: Posteroventral border deeply emarginated, with lateral lobes elongated (Fig. 5).

Female.—Coloration: Similar to male. Connexival segments VIII and IX reddish brown with posterior third yellow; abdominal segments VIII and IX reddish brown; genital plates reddish brown with internal angle of gonocoxae I yellow. Genital plates. Paratergite IX square, conspicuously devel-

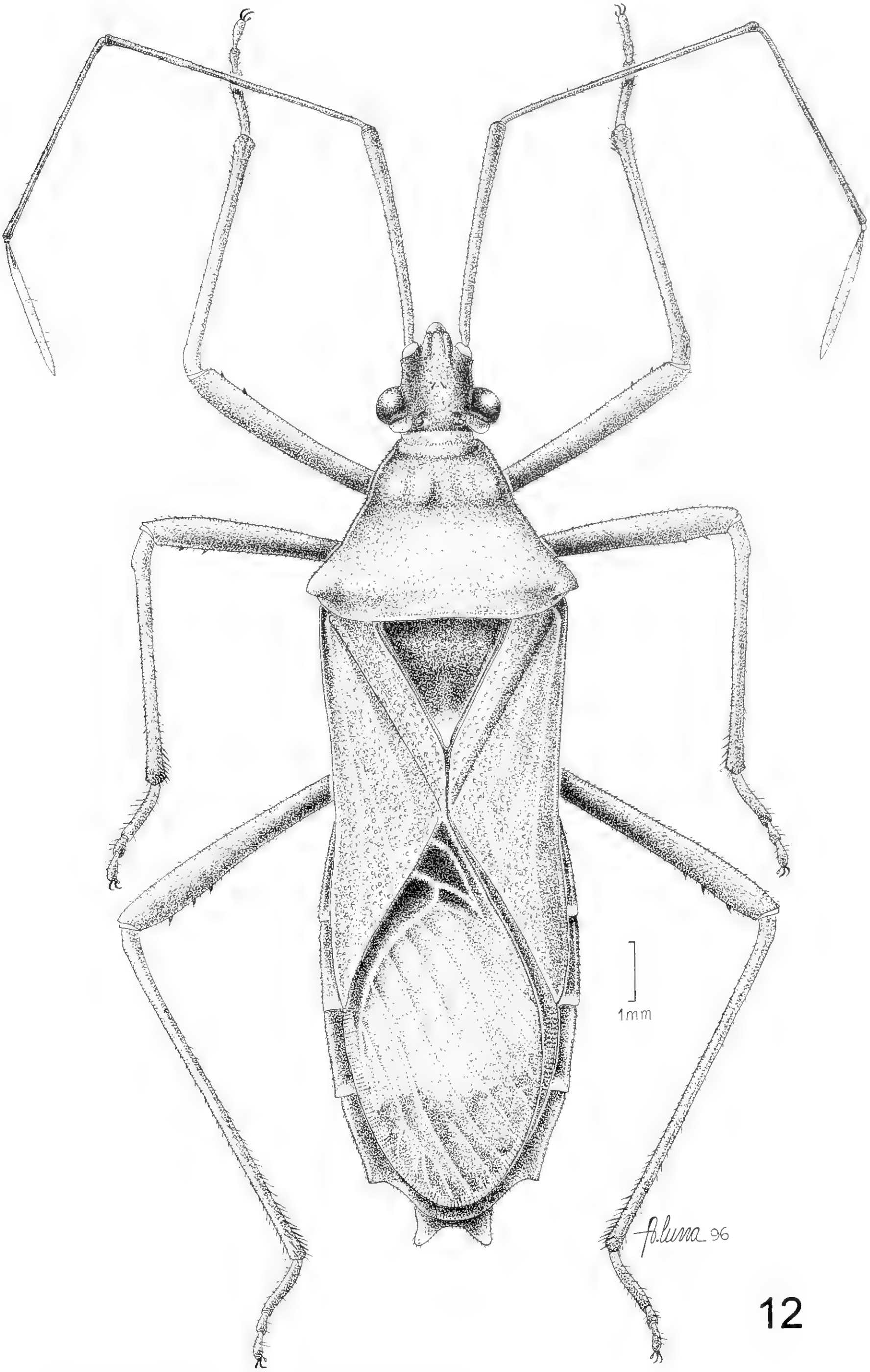

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Fig. 12. Dorsal view of *Hygia* (*Eucolpura*) *heveli*, male.

oped, extending beyond the external face of gonocoxae I, and with external margin slightly folded and curved (Fig. 8).

Variation.—The type material exhibits some color variation: 1, postocular tubercle entirely yellow; 2, space between eyes and ocelli yellow; 3, hemelytral membrane pale yellow with basal angle black; 4, femora orange yellow with reddish brown granules.

Type material.—Holotype: ♂, Malaysia, Sabah, 1 km., South of Kundasang, (1530 mts.), 28 August 1983, G.F. Hevel and W.E. Steiner (USNM). Paratypes: 2 ♀, same data as holotype (UNAM, USNM); 2 ♀, B.N. Borneo, Mt. Kinabalu, Kenokok (3300 ft), 23–25 April 1929 (BMNH); 2 ♀, B.N. Borneo, near Kinabalu, Tenompok (4700 ft), 18 May 1929 (BMNH, UNAM); 1 ♀, Borneo, Midden. 16 October 1925, H.C. Siebers (ZMUA).

Notes.—*Hygia* (*E.*) *heveli,* is similar to *H.* (*E.*) *lugubris* (Walker) and to *H.* (*E.*) *melas* Brailovsky and Barrera, in having the frontal angles of the pronotum rounded and not produced forward as conical teeth, and by the rostrum reaching anterior or middle third of abdominal sternite IV (occasionally anterior third of V). *Hygia* (*E.*) *heveli* is recognized by the shape of the posteroventral border of the male genital capsule (Fig. 5), for having paratergite IX conspicuously developed, with the external margin slightly folded and curved (Fig. 8), and by the length of the antennal segment II longer than 5.00mm. The length of segment II in other taxa is shorter than 4.50mm, and paratergite IX has the external margin conspicuously folded downward (*H.* (*E.*) *lugubris*) (Fig. 10) or has the external margin entire and not folded (*H.* (*E.*) *melas*) (Fig. 7).

Etymology.—Named for G. F. Hevel (USNM).

Distribution.—Known from the type localities.

KEY TO THE KNOWN SPECIES OF *HYGIA EUCOLPURA*

1. Hemelytral membrane with basal angle pale yellow brown . . . . *moesta* (Walker)
– Hemelytral membrane with basal angle black. 2
2. Posteroventral border of the male genital capsule simple, transversely straight with lateral angles nearly rounded . . . . *dolens* (Breddin)
– Posteroventral border of the male genital capsule not transversely straight, with rounded lateral angles (Figs. 1–3). 3
3. Frontal angles of the pronotum produced forward as small conical teeth. . .*scrutatrix* (Breddin)
– Frontal angles of the pronotum rounded. 4
4. Posteroventral border of the male genital capsule lateraly delimited by two remarkably pronounced arms (Fig. 1); paratergite IX with the external margin entire and not folded (Fig. 7) . . . . . .*melas* Brailovsky and Barrera new species
– Posteroventral border of male genital capsule delimited by much shorter arms; paratergite IX folded. 5
5. Posteroventral border of the male genital capsule deeply emarginated, with lateral lobes elongated (Fig. 5); paratergite IX with the external margin slightly folded and curved (Fig. 8) . . . .*heveli* Brailovsky and Barrera new species
– Posteroventral border of the male genital capsule with a short plate, having a sharp inwardly curving spine on each side (Fig. 3); paratergite IX with the external margin conspicuously folded downward (Fig. 10) . . . *lugubris* (Walker)

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A NEW AGONOXENINE MOTH DAMAGING *ARAUCARIA ARAUCANA* NEEDLES IN WESTERN ARGENTINA AND NOTES ON THE NEOTROPICAL AGONOXENINE FAUNA (LEPIDOPTERA: GELECHIOIDEA: ELACHISTIDAE)

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Abstract.—Characters of the adult, pupa, and larva of ***Araucarivora gentilii,*** new genus and new species, are illustrated. The needle mining larvae cause conspicuous browning to monkey-puzzle tree in west-central Argentina. The check list of Neotropical Lepidoptera is revised to accomodate genera and species newly assigned to Agonoxeninae. A list of taxa removed from Agonoxeninae and placed in other families/subfamilies is provided. Five genera are transferred to new family/subfamily associations. One new generic synonym and 23 new combinations are proposed.

Key Words: Classification, check list, Cosmopterigidae, Chrysopeleiinae, life history, morphology, needle miner

In 1994 Mario Gentili (San Martín de los Andes, Neuquén, Argentina) noticed severe browning of needle tips of *Araucaria araucana* (Molina), K. Koch (Araucariaceae) throughout the area. He enclosed several twigs and waited for adults to emerge to learn what was causing this damage. The adults represent an undescribed species and genus of the moth family Elachistidae, subfamily Agonoxeninae. They are characterized as follows.

Araucarivora Hodges, new genus

Type species: Araucarivora gentilii Hodges

Diagnosis.—Antenna without pecten; forewing with well-developed stigma; valva with free costal lobe, arms of gnathos free, ventral surface of each with very fine spicules; apophyses anteriores and apophyses posteriores absent; larva lacking prolegs on A5 and A6.

Description.—Forewing (Fig. 2): broadly lanceolate, stigma well developed; R_3, R_4, R_5 stalked, R_5 to anterior margin; M_1–CuA_2 separate; CuP present at margin; 1A and 2A forked at base, 1A weak. Hindwing (Fig. 3): lanceolate; R_1 weak, to Sc at ⅕ wing length; Rs–M_3 separate; M_3 and CuA_1 connate; CuA_2 from ⅓ wing length, 1A and 2A forked at base, 1A weak; retinaculum of female diffuse, anteriorly directed scales between R and CuA. Abdomen: Sternum 2 with long, somewhat diffuse venulae, venulae extending anteriorly but not as apodemes (Fig. 6); segment 8 not modified. Male genitalia (Figs. 4–5): Vinculum a slender band, slightly expanded distally in saccal region; aedeagus with recurved flange at apex; juxta with pair of lateral lobes, each setose at apex; gnathos expanded distally; uncus narrowly triangular, anterolateral margin slightly excavated. Female genitalia (Fig. 7): Apophysis anterioris and posterioris absent; sternum 8 sclerotized laterally and posterad of ostium

Fig. 1. *Araucarivora gentilii,* habitus.

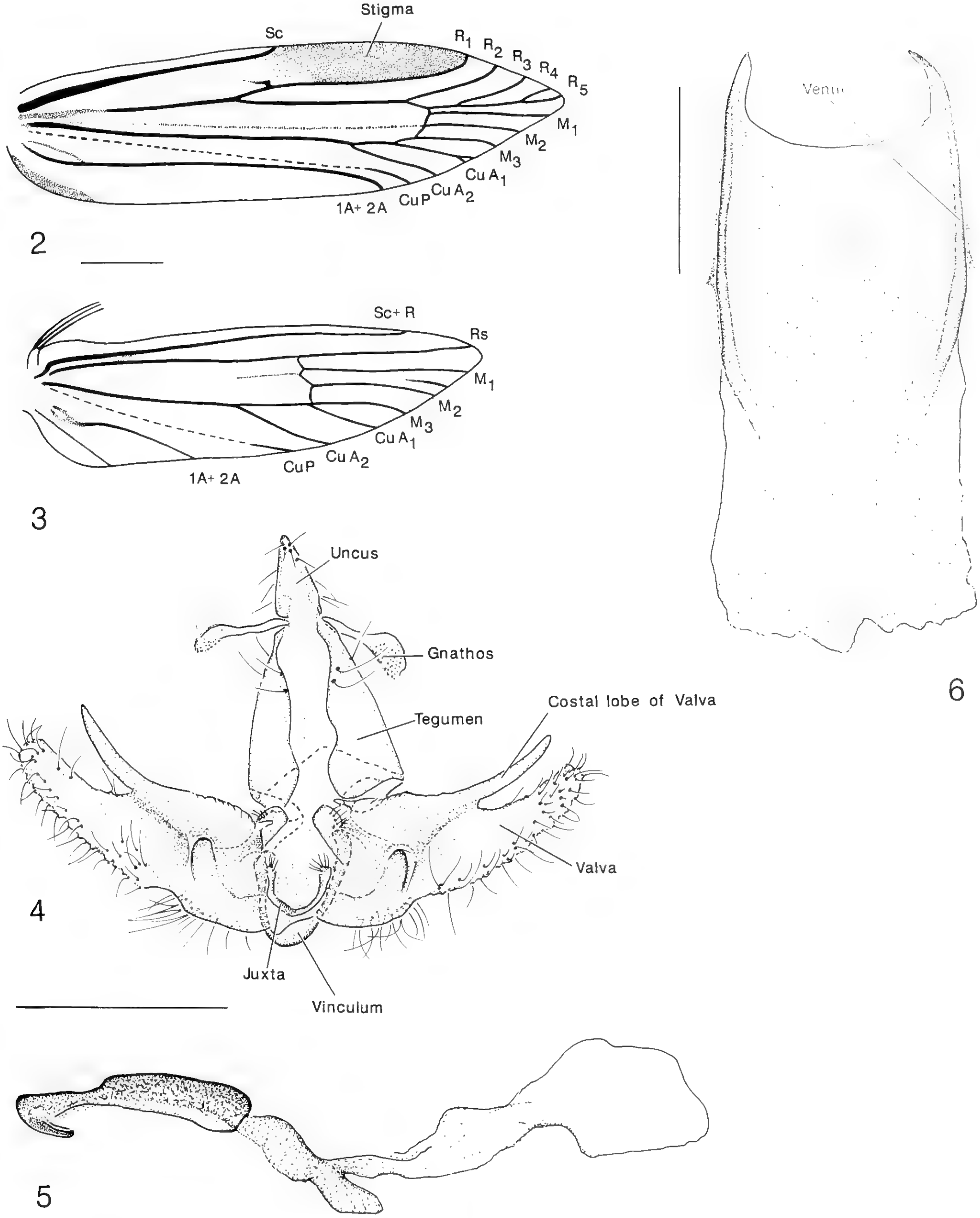
bursae; ostium bursae on anterior margin of sternum 8; ductus seminalis arising just beyond base of ductus bursae; corpus bursae finely spiculose; signum a lightly sclerotized, irregular plate with several inwardly directed projections; papilla analis blunt, densely setose on dorsal surface. Pupa (Figs. 8, 24–27): antennae meeting at ¾–⅘ their length, then diverging, exposing hindtarsi, extending to posterior margin of A4; maxillary palpus, femur 1, femur 2 visible; vertex, patagium, and anterior part of T2 coarsely spiculose; surface of wing finely spiculose; lateral condyles present on anterior margins of A5–7; well-developed "pupal legs" present on A9, each with many recurved setae at apex (Figs. 26–27); cremaster absent, several recurved setae present on A10 (Fig. 26). Larva (Figs. 9–23): Frons extending ¾ distance to epicranial notch; stemmata well separated from each other (Fig. 10); P_1 setae more distant from each other than P_2 setae (Fig. 11); body densely and coarsely spiculose; prothoracic shield and pinacula heavily sclerotized, latter relatively large; secondary setae apparently absent, except few on L group of A9; spiracle on T1 approximately 2× diameter of those on A1–7, spiracle on A8 larger than that on T1; tarsal setae setiform (Fig. 18); prolegs present on A3 and A4 (Fig. 20), absent on A5 and A6; crochets short, in circle, 15–16 (Fig. 21); 12–15 crochets on A10 in irregular line; A1, A2 with one SV seta; A7–8 with one SV seta; A8 with L1 dorsad of spiracle; A9 with 6–7 SV setae; A9 with D2 setae on separate pinacula, D1 seta slightly anterad of D2 and SD1.

Superficially, adults of *Araucarivora gentilii* are similar to some species of *Tetanocentria* Rebel but differ in the lack of a color pattern on the forewings. The presence of a stigma on the forewing, absence of apophyses in the female, and absence of prolegs on larval A5 and A6 are unique character states in Agonoxeninae.

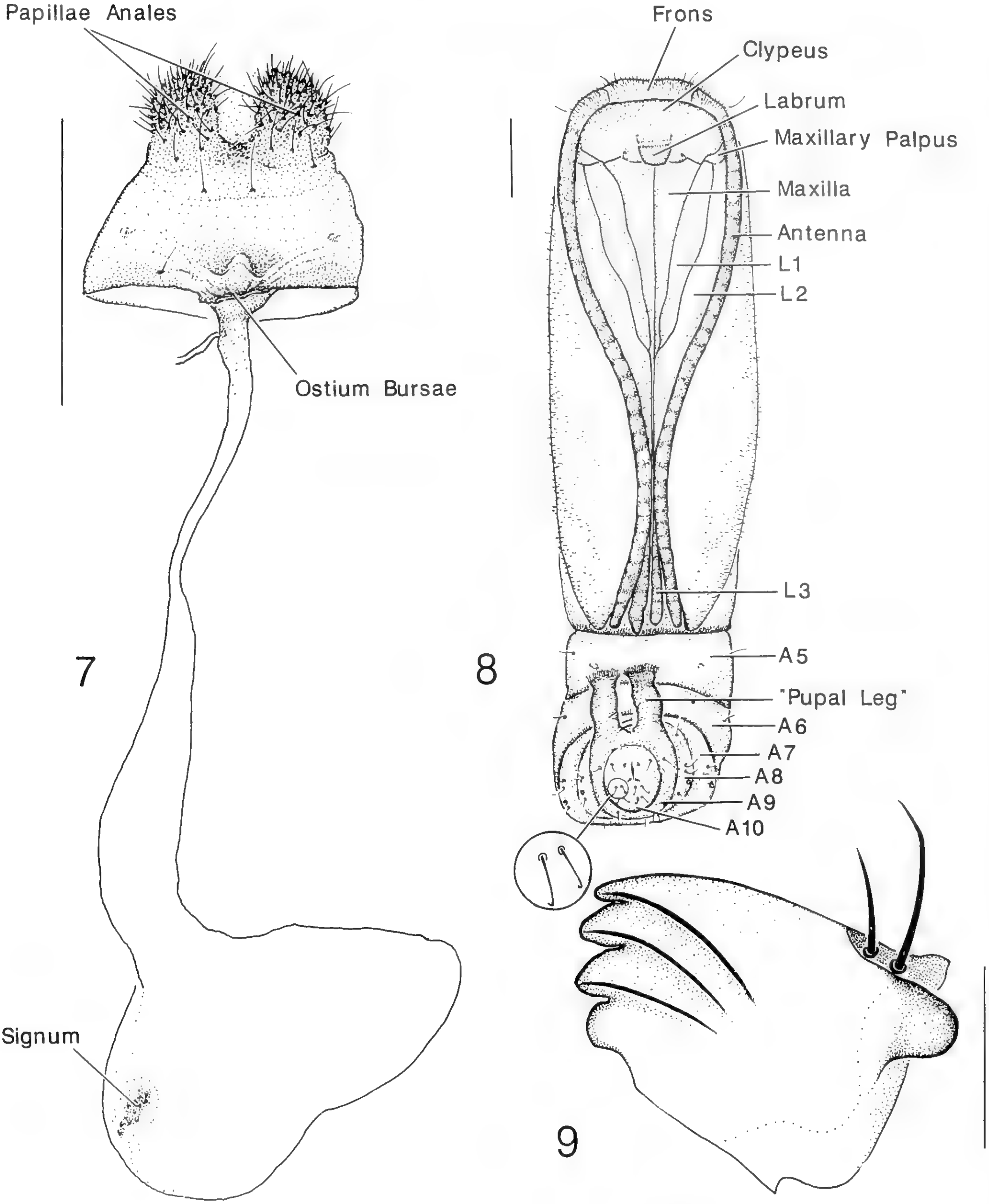
***Araucarivora gentilii* Hodges, new species**

Diagnosis.—The character states given for the genus will serve to diagnose the species.

Description.—Moth nearly uniformly dark gray brown on dorsal surface (Fig. 1). Head: Scales on haustellum pale yellow on basal ⅓; maxillary palpus gray on dorsal surface, yellowish gray ventrally; labial palpus slender, 2nd and 3rd segments approximately equal in length, mainly white, first segment with pale-gray scales on dorsal surface, second segment with anterior margin broadly dark brown and a few dark-brown scales laterally in mesial ½, apex dark brown, third segment dark brown anteriorly, white posteriorly; antenna dark brown on dorsal surface at base, becoming dark yellowish gray, ventral surface of scape and basal ⅐ of shaft white/off-white. Forewing: Nearly immaculate, dark gray brown, tips of individual scales pale gray on distal ⅔ of wing, slightly gray on basal ⅓ of wing, base of each scale paler than mesial part. Hindwing: Darker brown than forewing, fringe nearly same color as wing; prominent patch of white/pale-gray scales extending from base along costal margin to

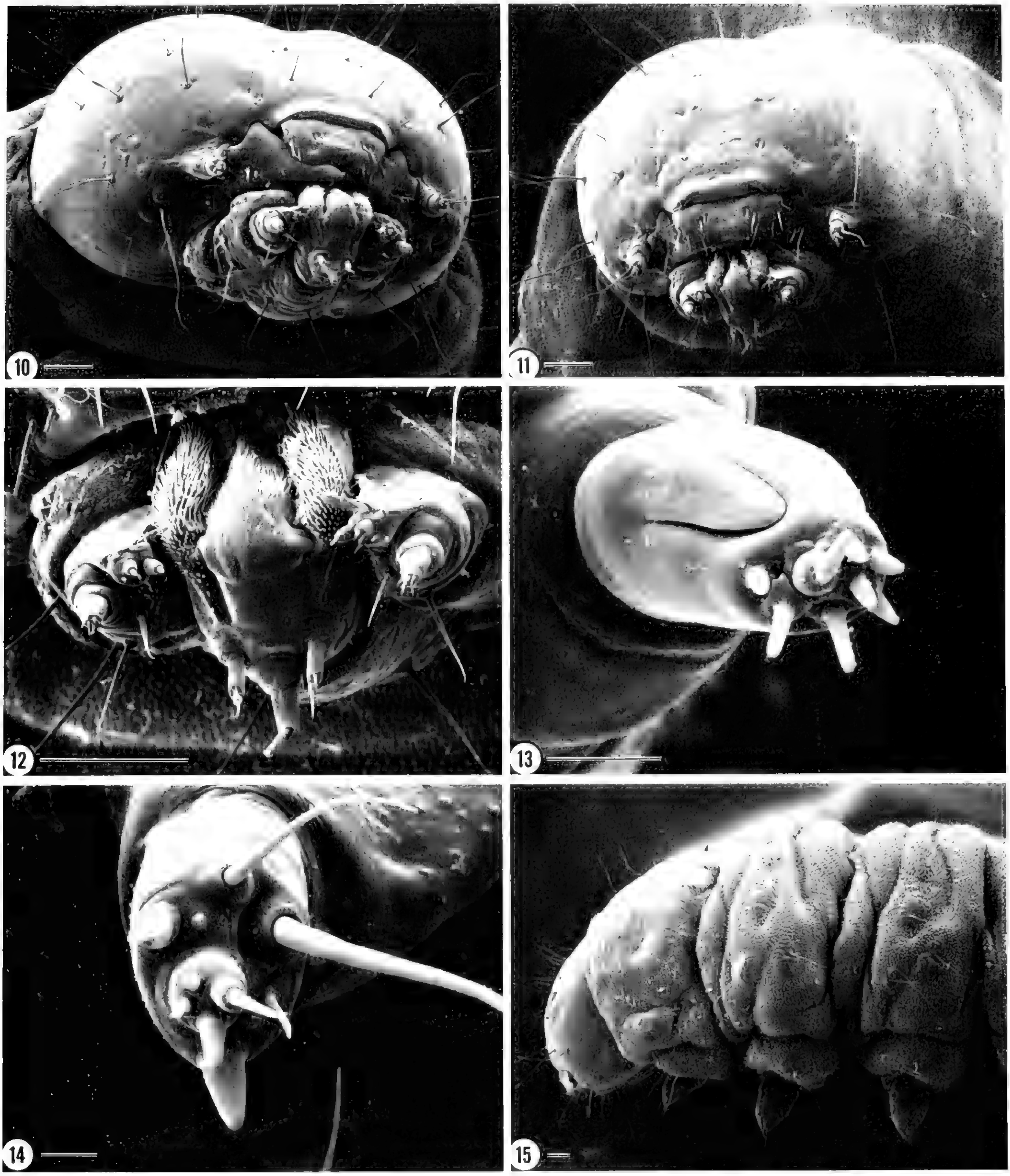


Figs. 2–6. *Araucarivora gentilii.* 2, Forewing [USNM slide 81596], line scale = 1.0 mm. 3, Hindwing [USNM slide 81596], line scale = 1.0 mm. 4, Male genitalia, posteroventral view, aedeagus removed [USNM 81594], line scale = 0.5 mm. 5, Aedeagus [USNM 81601], line scale = 0.5 mm. 6, Abdominal sternum 2, ♂ [USNM slide 81601], line scale = 0.5 mm.



Figs. 7–9. *Araucarivora gentilii.* 7, Female genitalia, ventral view [USNM 81595], line scale = 1.0 mm. 8, Pupa, ventral view, line scale = 1.0 mm. 9, Mandible, mesial view, line scale = 0.4 mm.

slightly beyond ½ wing length and posterad into cell, narrowing at apex. Legs: Scales appressed to segments, except dorsal surface of hindtibia with long, slender scales. Foreleg: Coxa and trochanter shining dark gray; femur mainly dark brown with pale gray on ventral margin; tibia and tarsus similarly colored, ventral margin nearly



Figs. 10–15. *Araucarivora gentilii*, larva. 10, Head capsule, lateroventral view, line scale = 100 μm. 11, Head capsule, anterior view, line scale = 100 μm. 12, Head capsule, ventral mouth area, line scale = 100 μm. 13, Maxillary palpus, anteromesial view, line scale = 10 μm. 14, Antenna, anterior view, line scale = 10 μm. 15, Head and thorax, lateral view, line scale = 10 μm.

white. Mid- and hindlegs: Similar to foreleg but with more pale scales. Abdomen: Mainly dark brown dorsally, scales on posterior margin of last two segments dark, slightly yellowish gray; ventral surface mainly pale gray with yellowish cast, anterior part of many segments with yellowish-brown scales. Wing length 5.8–6.0 mm.

Types.—Holotype ♀. Argentina, Neuquén, San Martín de los Andes; $^{13}/_{16}$ I 1995;

M. Gentili; ex needle mine *Araucaria araucana.* USNM [National Museum of Natural History, Washington]. Paratypes: 4 ♂, 11 ♀. Each with same data as for holotype; USNM slides 81594–81596, 81600–81602. Paratypes to The Natural History Museum, London, BM(NH); M. Gentili; USNM. In addition several larvae, pupae, and pupal skins are preserved in alcohol in the USNM.

Larvae make a large blotch mine in the distal part of the very broad needles of *Araucaria araucana.* Frass remains in the mine. Pupation occurs in the mine. Before pupating the larva cuts a nearly round hole through which the adult emerges. Because less than ⅓ of each needle is eaten by the larva, damage to the tree probably is mainly cosmetic. However, because the needles remain on the tree for several years, the heavily infested trees present a highly unattractive appearance.

TAXONOMIC SUMMARY OF NEOTROPICAL MOTHS FORMERLY ASSIGNED TO AGONOXENINAE

Agonoxeninae are relatively poorly known, but I give a short summary on their classification (Hodges, in press) in the forthcoming volume on Lepidoptera in the *Handbook of Zoology.* The major literature is contained in Bottimer (1926), Bradley (1966), Clarke (1965a, b), Common (1990), Hodges (1978), Kasy (1976), Kuznetsov, N. J. (1916), Riedl (1969), and Stehr (1987). Worldwide 23 genera and 95 species are known. Becker (1984b) listed nine genera and 42 species for the Neotropical Region. That document is modified to accomodate transfer of genera among families and subfamilies and species among genera.

Amblytenes Meyrick, 1930 (type species *lunatica* Meyrick) is here transferred from Batrachedrinae.

Auxotricha Meyrick, 1931b (type species *ochrogypsa* Meyrick) was transferred from Depressariinae by Minet, 1990.

Glaucacna Forbes, 1931 (type species *iridea* Forbes) is here transferred from Gelechiinae.

Nicanthes Meyrick, 1928 (type species *rhodoclea* Meyrick) is known from a single female. The genital characters suggest that it belongs in Gelechioidea (possibly Gelechiinae) but not in Agonoxeninae.

Pammeces citraula Meyrick, 1922: 584 is here transferred to *Homaledra* (Batrachedrinae), **NEW COMBINATION.**

Pammeces crocoxysta Meyrick, 1922: 584 is here transferred to *Homaledra* (Batrachedrinae), **NEW COMBINATION.**

Panclintis Meyrick, 1929 (type species *socia* Meyrick) is here transferred to Gelechioidea (without family placement). *Panclintis socia* has an ocellus; no Agonoxeninae have ocelli.

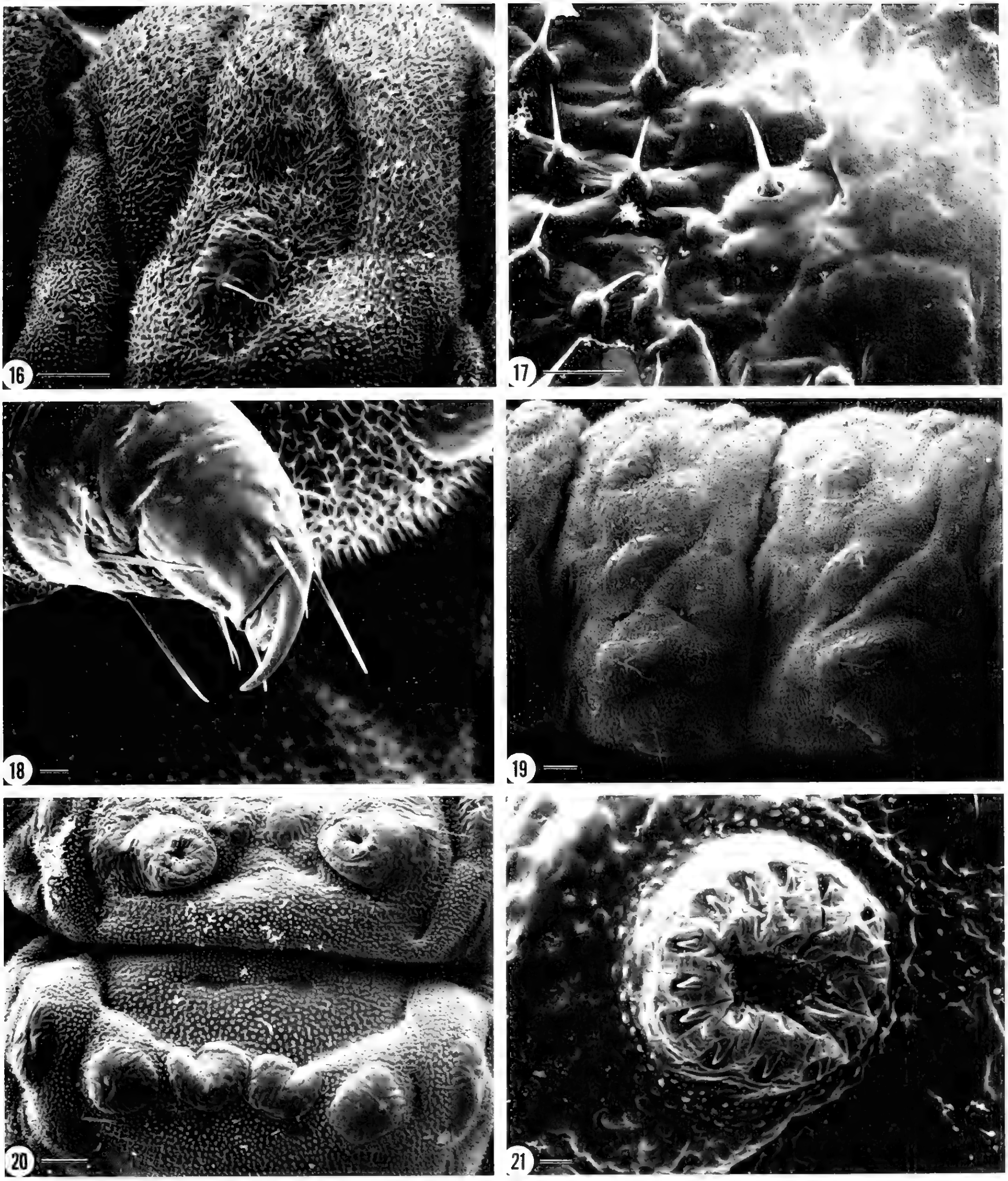
Prochola Meyrick, 1915 (type species *oppidana* Meyrick) is here transferred to Cosmopterigidae, Chrysopeleiinae. The male genitalia of the lectotype of *Prochola oppidana* (Clarke, 1965b: pl. 255) indicate that the genus is a chrysopeleiine. It appears to represent a valid genus. Examination of the genitalia of one of the specimens in the type series demonstrates that Meyrick had a mixed series; the male genitalia of this specimen (USNM genitalia slide 87690) indicate that it is a species of *Periploca* Braun. Eighteen species of *Prochola* of Becker's list (1984b: 43) are given new assignments in the following taxonomic summary.

Syntetrernis neocompsa Meyrick, 1933: 428 is here transferred to *Scythris,* Scythrididae, **NEW COMBINATION.**

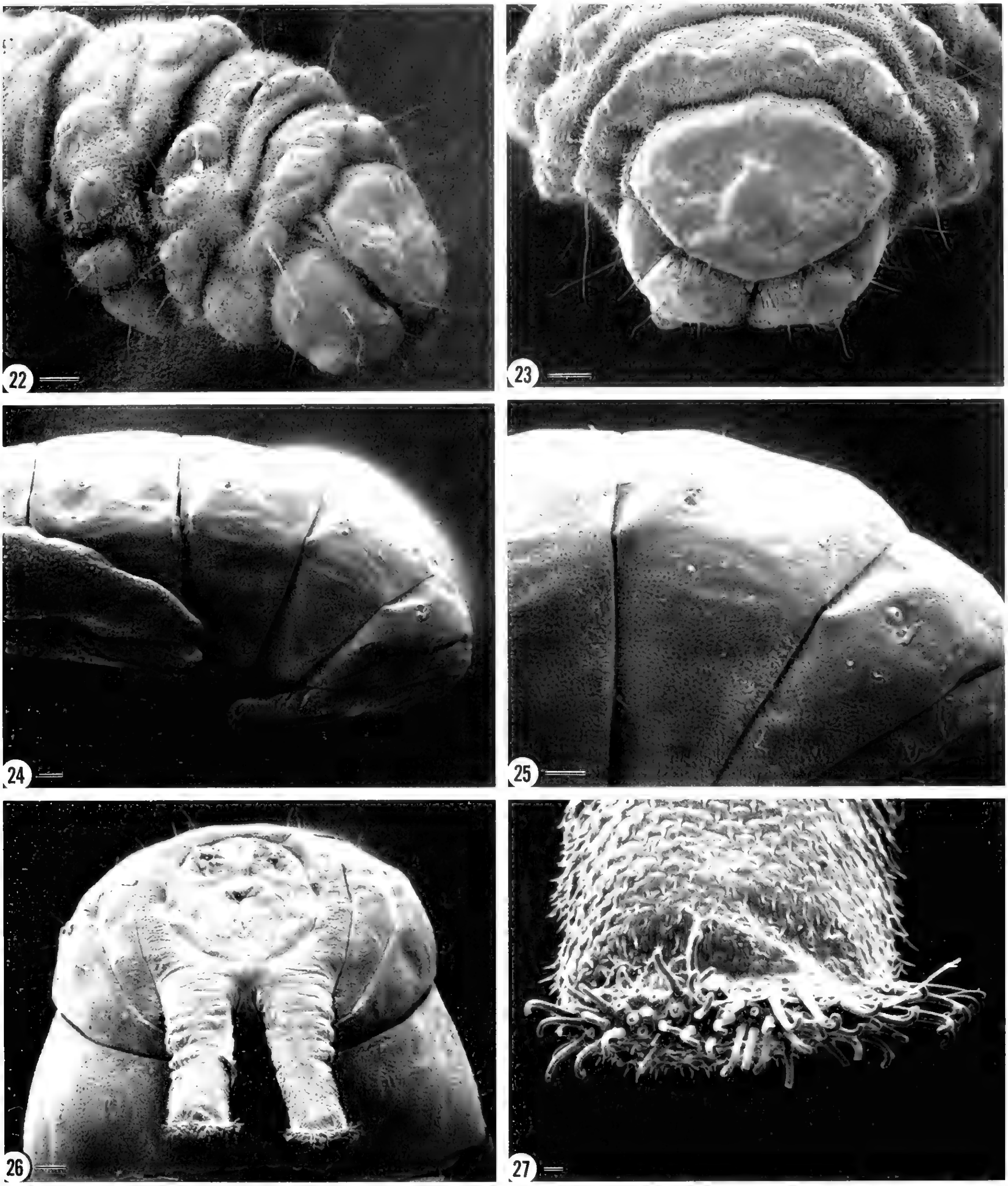
Tocasta Busck, 1912 (type species *priscella* Busck) was transferred from Coleophorinae by Baldizzone, 1989.

Study of *Eritarbes guttata* Busck shows that it belongs in *Tetanocentria*; it is transferred below. *Eritarbes otiosa* Walsingham, 1909, the type species of *Eritarbes,* is a species of *Ithome*; thus, *Eritarbes* is a junior synonym of *Ithome* Chambers, 1875.

The result of this research is summarized in the following revised check list of Neo-



Figs. 16–21. *Araucarivora gentilii*, larva. 16, Thoracic segment 2 with L setae, lateral view, line scale = 100 μm. 17, Thoracic segment 3, seta SD1, spinules, line scale = 10 μm. 18, Thoracic leg 2, apex, line scale = 10 μm. 19, Abdominal segments 4–5, lateral view, lateral view, line scale = 100 μm. 20, Abdominal segments 4–5, ventral view, lateral view, line scale = 100 μm. 21, Proleg and crochets, abdominal segment 4, ventral view, line scale = 10 μm.



Figs. 22–27. *Araucarivora gentilii.* 22, Larva, lateral view of abdominal segments 7–10, line scale = 100 µm. 23, Larva, dorsal view of abdominal segments 9–10, line scale = 100 µm. 24, Pupa, lateral view of segments 4–10, line scale = 100 µm. 25, Pupa, lateral view of segments 4–7, showing lateral condyles, line scale = 100 µm. 26, Pupa, posteroventral view of segments 6–10, showing "pupal legs," line scale = 100 µm. 27, Pupa, apex of "pupal leg," line scale = 10 µm.

tropical Agonoxeninae and pertinent Chrysopeleiinae.

AGONOXENINAE

Parametriotini

Araucarivora Hodges, new genus

gentilii Hodges, new species

Auxotricha Meyrick, 1931b: 189

ochrogypsa Meyrick, 1931b: 190 [lectotype illustrated by Clarke, 1963: pl. 60]

Glaucacna Forbes, 1931: 369

iridea Forbes, 1931: 369 [illustrated by Forbes, 1931]

Homoeoprepes Walsingham, 1909: 10

felisae Clarke, 1962: 375 [genital slides of type series studied]

sympatrica Clarke, 1962: 381 [genital slides of type series studied]

trochiloides Walsingham, 1909: 10 [illustrated by Clarke, 1962: Fig. 3; holotype without abdomen; male unknown]

Microcolona Meyrick, 1897: 370

transennata Meyrick, 1922: 575 [lectotype illustrated by Clarke, 1965b: pl. 251]

Nanodacna Clarke, 1964: 125

ancora Clarke, 1964: 126 [genital slides of type series studied]

indiscriminata Clarke, 1965a: 93 [genital slides of type series studied]

logistica (Meyrick, 1931c: 387, *Colonophora*)

vinacea (Meyrick, 1922: 574, *Homaledra*)

Pammeces Zeller, 1863: 152

albivitella Zeller, 1863: 152 [type not studied]

lithochroma Walsingham, 1897: 103 [type not studied]

pallida Walsingham, 1897: 103 [type not studied]

phlogophora Walsingham, 1909: 11 [type not studied]

problema Walsingham, 1915: 458 [type not studied]

Tetanocentria Rebel, 1902: 107

Aetia Chambers, 1880: 186, preoccupied by Agassiz, 1847: 10

Platybathra Meyrick, 1912: 78

Parametriotes Kuznetsov, N. J. 1916: 628

Syntetrernis Meyrick, 1922: 573

Chaetocampa Busck, 1926: 804

agypsota (Meyrick, 1922: 580, *Prochola*), NEW COMBINATION [type illustrated by Clarke, 1965b: pl. 256]

catacentra (Meyrick, 1922: 582, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 256]

catholica (Meyrick, 1917: 46, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 256]

guttata (Busck, 1914: 1, *Eritarbes*), NEW COMBINATION [genitalia of paratype studied]

sollers (Meyrick, 1917: 46, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 259]

subtincta (Meyrick, 1922: 574, *Syntetrernis*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 259]

xiphodes (Meyrick, 1922: 574, *Syntetrernis*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 278]

Tocasta Busck, 1912: 4

Amblytenes Meyrick, 1930: 229, NEW SYONYMY [*Amblytenes* is transferred from Batrachedrinae]

lunatica (Meyrick, 1930: 230, *Amblytenes*), NEW COMBINATION [genitalia of type studied]

priscella Busck, 1912: 4 [genitalia of type studied]

revecta (Meyrick, 1922: 582, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 259]

Zaratha Walker, 1864: 789

[preliminary study of superficially similar species from the Neotropics resulted in discovery of 11 segregates based on genitalia.]

macrocera C. Felder & Rogenhofer, 1875: pl. 140, Fig. 18 [Becker, 1984a: 248

illustrated a specimen from Costa Rica that matches the abdomenless lectotype]

mesonyctia Meyrick, 1909: 17 [type not studied]

pterodactylella Walker, 1864: 790 [lectotype illustrated by Becker, 1984a: 248]

niveiventris C. Felder & Rogenhofer, 1875: pl. 140, fig. 26 [type lost]

COSMOPTERIGIDAE

Chrysopeleiinae

Ithome Chambers, 1875: 93

Eritarbes Walsingham, 1909: 7, NEW SYNONYMY

fuscula (Forbes, 1931: 357, *Prochola*), NEW COMBINATION [paratype examined]

otiosa (Walsingham, 1909: 7, *Eritarbes*), NEW COMBINATION [paratypes examined]

Periploca Braun, 1919: 261

aedilis (Meyrick, 1915: 331, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 255]

basichlora (Meyrick, 1922: 582, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 255]

chloropis (Meyrick, 1922: 580, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 256]

euclina (Meyrick, 1922: 583, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 257]

obstructa (Meyrick, 1915: 332, *Prochola*), NEW COMBINATION [holotype illustrated by Clarke, 1965b: pl. 257]

orphnopa (Meyrick, 1922: 582, *Prochola*), NEW COMBINATION [holotype illustrated by Clarke, 1965b: pl. 258]

orthobasis (Meyrick, 1922: 582, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 258]

prasophanes (Meyrick, 1922: 581, *Prochola*), NEW COMBINATION [holotype illustrated by Clarke, 1965b: pl. 258]

semialbata (Meyrick, 1922: 581, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 259]

Prochola Meyrick, 1915: 331

oppidana Meyrick, 1915: 331 [lectotype illustrated by Clarke, 1965b: pl. 255]

pervallata Meyrick, 1922: 581, MISPLACED [lectotype illustrated by Clarke, 1965b: pl. 258]

Siskiwitia Hodges, 1969: 10

holomorpha (Meyrick, 1931a: 282, *Prochola*), NEW COMBINATION [holotype illustrated by Clarke, 1965b: pl. 257]

Stilbosis Clemens, 1860: 170

Aeaea Chambers, 1874: 73.

Amaurogramma Braun, 1919: 261

ochromicta (Meyrick, 1922: 580, *Prochola*), NEW COMBINATION [lectotype illustrated by Clarke, 1965b: pl. 257]

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LIMOMYZA, A NEW GENUS OF PRIMITIVE LIMOSININAE (DIPTERA: SPHAEROCERIDAE), WITH FIVE NEW SPECIES FROM UNITED STATES, MEXICO, AND CENTRAL AMERICA

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Abstract.—The new genus ***Limomyza*** is described and included in the Limosininae primarily on the basis of its wing venation, despite the overall close similarity of ***Limomyza*** species to members of the Copromyzinae. Five new species of ***Limomyza*** are described and keyed, including the type species ***L. cavernicola*** from United States, ***L. venia, L. archiptera*** and ***L. hirta*** from Mexico, and ***L. sharkeyi*** from Guatemala and Mexico.

Key Words: Sphaeroceridae, Diptera, taxonomy, Limosininae

The new genus *Limomyza* is diagnosed on the basis of a complete cell *cup*, an open cell bm, a mid ventral hind tibial bristle, and a large inclinate orbital bristle between the upper exclinate orbital and inner vertical bristles. *Limomyza* challenges current subfamilial concepts in the Sphaeroceridae, because it presents an apparent mosaic of characters previously used to diagnose the subfamilies Copromyzinae and Limosininae. Although *Limomyza* species are generally most similar to the Copromyzinae, they show some of the reductions in wing venation characteristic of the Limosininae. The main lineages of Sphaeroceridae are therefore briefly reviewed below prior to description of *Limomyza* as a limosinine.

THE MAIN LINEAGES OF SPHAEROCERIDAE

The Sphaeroceridae can be broken into 3 lineages, as follows:

Tucminae.—This is the sister group to the rest of the family, and contains only the genus *Tucma* Mourgués-Schurter. *Tucma* retains a well developed male tergite 6, the loss of which appears to be a synapomorphy of the rest of the family (Marshall 1996).

Limosininae.—The Limosininae (including the vast majority of the species in the Sphaeroceridae) is characterised by the loss of crossvein bm-cu (i.e. cells bm and dm fused; also the case in the putative copromyzines *Palaeolimisina* and *Palaeoceroptera*), reduction of the distal part of vein M (also reduced in *Palaeoceroptera*), and usually the loss of *cup,* elongation of the arista, and a head which is distinctly higher than long.

Sphaerocerinae plus Copromyzinae.—The Sphaerocerinae plus the Copromyzinae form a clade characterised by an epandrium with a deep (Copromyzinae) or complete (Sphaerocerinae) lateral cleft. The epandrial cleft is absent in one monophyletic group currently included in the Copromyzinae (a group including *Lotophila* Lioy, *Borborillus* Duda, *Dudaia* Hedicke, *Gymnometopina* Hedicke, *Metaborborus* Vanschuytbroek, and *Afroborborus* Curran) but, as interpreted by Norrbom and Kim (1984), the epandrial cleft has been lost in these genera. An epandrium that is completely divided, presumably by development of the epandrial cleft, is one of several apomorphic characters defining the Sphaerocerinae, but the Copromyzinae is currently defined only on plesiomorphic characters (cells bm and *cup* complete, vein M reaching the wing margin, costa reaching the tip of vein M, long and telescoping female abdomen, strongly setose tibia, simple, narrow-based surstylus).

SUBFAMILIAL PLACEMENT OF *LIMOMYZA*

Limomyza species are very much like the Copromyzinae in general habitus, with long, telescoping female terminalia, inclinate inner orbital setulae, hind tibia with dorsal and ventral bristles, richly setose tibiae, and a fully developed cell *cup*. The male terminalia, with broadly fused, posteriorly lobate cerci; elongate, simple surstyli; and a large epiphallus are also more similar to copromyzines than most limosinines. These, however, are all plesiomorphic characters. One possible apomorphic character linking *Limomyza* to the Copromyzinae is the absence of a ring sclerite in the membrane of the male sixth abdominal segment. *Tucma* and most Limosininae have a translucent circular plate, usually ringed by a darkened sclerite, in the membrane immediately behind the sixth right spiracle of the male abdomen. This ring sclerite (possibly a large campaneiform sensillum) is completely absent from *Limomyza,* copromyzines, and sphaerocerines. Despite the superficial similarity between *Limomyza* and Compromyzines, the loss of the ring sclerite is the only apparently apomorphic character supporting a relationship between *Limomyza* and all or part of the sphaerocerine-copromyzine lineage. On the other hand, three characters seem to support the inclusion of *Limomyza* in the Limosininae. The head is almost 1.5× as high as long, in contrast to most Copromyzinae, in which the head is usually almost as long as high. There is considerable variation in head shape within both groups, so the value of this character is questionable. The other two characters suggesting that *Limomyza* belongs in the Limosininae are venational characters. It is largely on the basis of these characters, the lack of a closed cell bm and M not reaching the wing margin, that *Limomyza* is placed in the Limosininae.

Most other sphaerocerid genera with a closed cell *cup* but without a closed cell bm also belong in the Limosininae, and all such genera were included in this group (as Leptocerinae) by Hackman (1969). These include the *Archileptocera* genus-group (*Anomioptera* Schiner, *Archileptocera* Duda, and *Palaeocoprina* Duda), *Hellerella* Duda, *Palaeoceroptera* Duda, *Palaeolimosina* Duda, and *Palaeoceroptera* Duda. All of these taxa except *Anomioptera* have been treated as subgenera of *Archileptocera,* but are elevated to genus and keyed by Marshall (in press). *Palaeolimosina* and *Palaeoceroptera* are like *Limomyza* in having a copromyzine-like habitus. *Palaeolimosina* is known only from a single, damaged female specimen with short antennae and M reaching the wing margin, and probably belongs in the Copromyzinae. *Palaeoceroptera* is the genus most similar to *Limomyza,* but the one species of *Palaeoceroptera* known from males has an epandrial cleft, which suggests that this genus also belongs in the Copromyzinae, or at least in the sphaerocerine-copromyzine clade. Both *Palaeoceroptera* and *Palaeolimosina* are known only from the southern hemisphere, and lack the defining characters of *Limomyza* as listed below.

Following Cumming et al. (1995), and Wheeler (1995), terminology used here for some structures of the male and female terminalia differs from that of McAlpine (1981), and from this author's earlier papers on New World Sphaeroceridae. The term gonostylus is used for the structure previously referred to as the paramere, and the term subepandrial sclerite is used for the sclerite previously called sternite 10. Morphological terminology for female terminalia follows that of McAlpine (1981) with the exception of the terminal tergites and sternites, here called tergite and sternite 10 rather than epiproct and hypoproct.

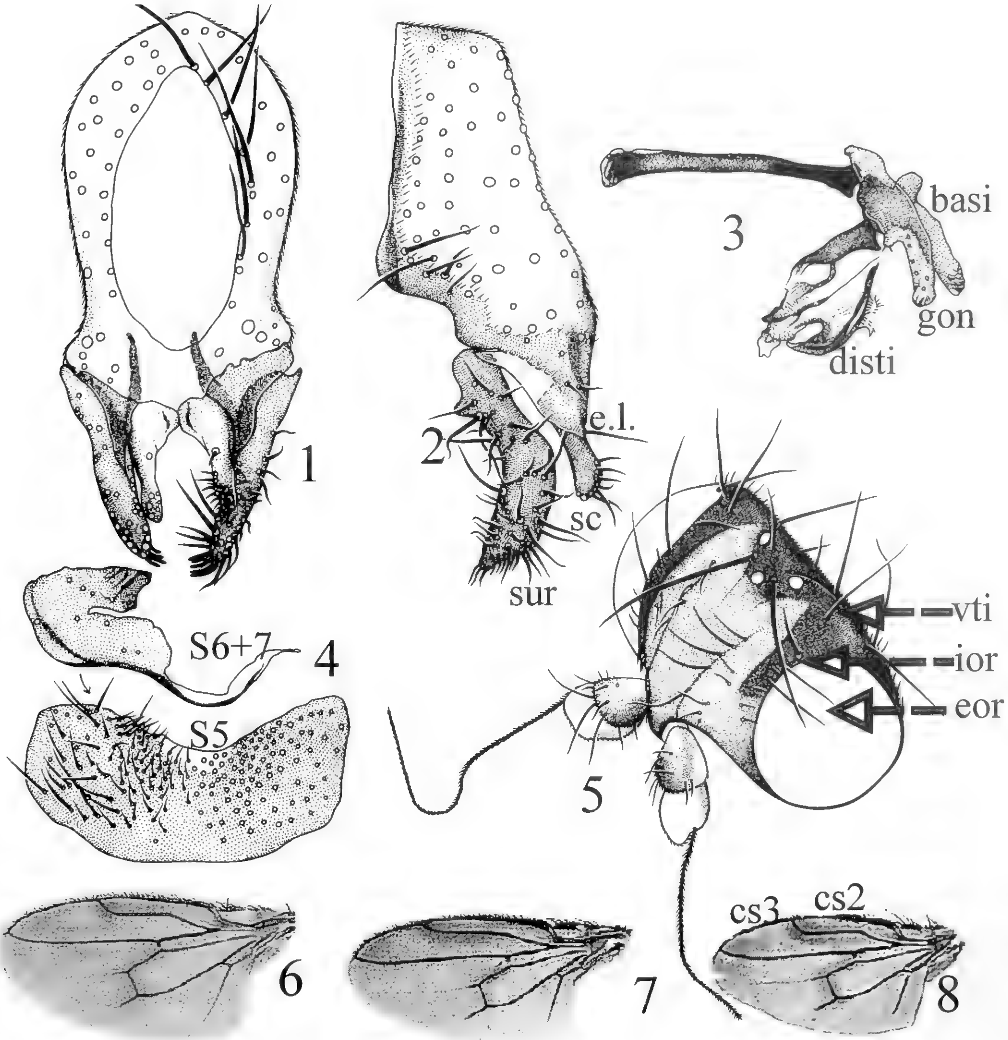
Limomyza Marshall, new genus

Type species: Limomyza cavernicola, New Species.

Defining and diagnostic characters.—*Limomyza* differs from all other sphaerocerids with a cell *cup* but no basal medial cell in having a mid-ventral hind tibial bristle, a bristle between the orbital and inner vertical bristles, and only one pair of (prescutellar) dorsocentral bristles. The absence of setae on the scutellar surface and the inclinate row of inner orbital setulae are also diagnostic.

Generic description.—Body length usually 3–5 mm; body color black to dark reddish brown; most of frons and antennae reddish, vertex, orbits, interfrontal strips, ocellar triangle, and middle of interfrontal area silvery pruinose. One or 2 rows of inclinate inner orbital setulae present midway between orbital and interfrontal bristles; a single inclinate orbital bristle present above upper exclinate orbital bristle, between upper orbital and inner vertical bristle (Fig. 5) (other sphaerocerids have 0–2 exclinate orbital bristles only, although some authors have called the inner vertical bristle an orbital bristle). Postocellar bristles cruciate; ocellar bristles strong. Face deeply concave, upper half carinate. Margin of labrum with a flat, triangular, pruinose median portion; clypeus black. First flagellomere apically flattened but not tapered; arista dorsal, hairs of medium length, arista slightly longer than head height. Eye 0.9–2.0× genal height. Mid tibia setose, upper surface with at least 3 anterodorsal bristles and 3 posterodorsal bristles, and 2–3 distal dorsal bristles (lower one large); lower surface with a midventral bristle, apex ringed with bristles. Hind tibia with a long, thin, distal dorsal bristle, a short midventral bristle, and a stout apical ventral bristle. Postpronotum with 2 bristles. Dorsocentral bristles in a single large prescutellar pair; acrostichal setulae long, dense, in 8–15 rows between dorsocentral areas. Scutellum broad, ca. 1.7× as broad as long, with 4 marginal bristles, disc microtrichose only. Halter pale. Wing with cell *cup* closed, vein Cu_2 strong; crossveins r-m and dm-cu separated by less than 1.5× length of dm; vein Cu_1 strong for some distance beyond crossvein dm-cu; R_{2+3} sinuate to sharply bent; C ending at apex of R_{4+5}; alula narrow or of medium width.

Male abdomen (*Limomyza sharkeyi* known from ♀ only): Sternite 5 dark except for a pale posteromedial area, densely setulose near posteromedial area. Membrane around and behind 6th right spiracle unmodified. Synsternite 6+7 simple, laterally setulose, dorsolaterally contiguous with sternite 8; sternite 8 shining, mostly bare, articulating with the shorter, setulose, epandrium at 2 widely separated points. Epandrium densely setose, with some long lateral bristles. Subepandrial sclerite well-developed, simple. Cerci broadly fused to form a very long subanal plate, ventrally projecting to form lobes here referred to as subcerci; posterolateral parts of epandrium swollen behind surstylar base and variously projecting ventrally as epandrial lobes; posteroventral part of epandrial lobe overlapping base of prominent subcercus. Surstylus elongate, narrow base articulated with epandrium and broad hypandrial arm. Hypandrium forked posteromedially; hypandrial arms free from hypandrial apodeme. Basiphallus with elongate epiphallus as long as or almost as long as gonostylus; distal part of basiphallus very small. Gonostylus narrow and parallel-sided distally, apex blunt, slightly bent anteriorly; basal part of gonostylus slightly broader than distal part, with a truncate anteroventral lobe. Distiphallus with a dark, hooked basal part and equal-length pairs of distal dorsal and distal ventral lobes separated by a conspicuous concavity. Female genitalia (*Limomyza hirta* known from ♂ only): Tergites 1–5 broad, heavily sclerotized; tergites 6–8 very narrow, pale, telescoped into preabdomen; tergites 6 & 7 divided into entire anterior parts and tripartite posterior parts; tergite 8



Figs. 1–8. 1–4, *Limomyza archiptera,* male. 1, Terminalia, posterior. 2, Terminalia, left lateral, hypandrium removed. 3, Phallus and associated structures. 4, Sternites 5–7. 5, *L. cavernicola,* head. 6, *L. archiptera,* wing. 7, *L. cavernicola,* wing. 8, *L. venia,* wing. Abbreviations: basi = basiphallus; disti = distiphallus; e.l. = epandrial lobe; gon = gonostylus; S5 = sternite 5; sc = subcercus; sur = surstylus; S6+7 = synsternite 6+7; cs2 = second costal sector; cs3 = third costal sector; vti = inner vertical bristle; ior = inclinate orbital bristle; eor = exclinate orbital bristles.

entirely tripartite, lateral parts shining and relatively dark. Tergite 10 small, with 2 small bristles; cerci setulose and apically setose. Sternite 8 bipartite, each half posteriorly setulose and with 2–3 bristles; sternite 10 uniformly, sparsely setulose, with 2 longer bristles. Spermathecae (3) oval to elongate, with transverse wrinkles, strongly tapered and usually curved basally.

Etymology: The name *Limomyza* is from a combination of the names of the type genera of Limosininae and Copromyzinae, and alludes to the copromyzine habitus of this limosinine genus.

BIOLOGY AND DISTRIBUTION OF *LIMOMYZA*

Collection records suggest that *Limomyza* species are primarily coprophagous, and that most species in the genus are associated with high elevations (over 2000 m) in Mexico and Central America. *Limomyza cavernicola,* which occurs in eastern and central United States, has been collected in caves.

KEY TO SPECIES OF *LIMOMYZA*

1. Eye very small, height less than genal height. Back of head densely setose, postocular bristles in double row on lower half and triple row on upper half. Proximal half of mid tibia with anterior and anterodorsal rows of bristles. Surstylus without row of bristles at apex (Figs. 16, 18). Known only from type locality in Durango, Mexico. . . . . . . *Limomyza hirta,* new species

– Eye larger, height at least 1.5× genal height. Postocular bristles forming a single row below and a double row near top of eye. Mid tibia with only anterodorsal and posterodorsal bristles proximally. Surstylus of known males with an apical row of stout bristles (Figs. 1, 10, 22). USA, Mexico and Central America. 2

2. Body length ca. 4 mm. Inclinate interfrontal setulae between orbital and interfrontal bristles extending at least up to level of upper interfrontal. Four large posterodorsal bristles on mid tibia. Pruinosity along posterior part of gena divided into small dorsal and extensive ventral parts. Mexico (Chiapas) and Guatemala (♀ only) . . . . . .*Limomyza sharkeyi,* new species

– Body length less than 3.5 mm. One row of 2–4 inclinate interfrontal setulae between lower orbital and interfrontal bristles; no setulae on upper half of frons. Three large posterodorsal bristles on mid tibia. Pruinosity continuous along posterior part of gena 3

3. Surstylus slender, width at ⅓ subequal to width at ⅔; distal comb on posterior surface and twice as long as maximum surstylar width (Fig. 21). Epandrial lobe acute. Mexico . . . .*Limomyza venia,* new species

– Surstylus slightly expanded and flattened distally, distal comb on posteroventral or ventral surface and less than twice as long as maximum surstylar width. Epandrial lobe blunt, strongly overlapping subcercus. 4

4. Second costal sector greater than 1.5× third costal sector; R2+3 weakly sinuate (Fig. 7). Distal comb of surstylus slightly longer than maximum surstylar width (Fig. 9). Eye ca. 1.6× genal height. USA . . . . *Limomyza cavernicola,* new species

– Second costal sector less than 1.3× third costal sector; R2+3 strongly sinuate (Fig. 6). Distal comb of surstylus subequal to maximum surstylar width (Fig. 2). Eye ca. 2.1× genal height. Mexico . . . . *Limomyza archiptera,* new species

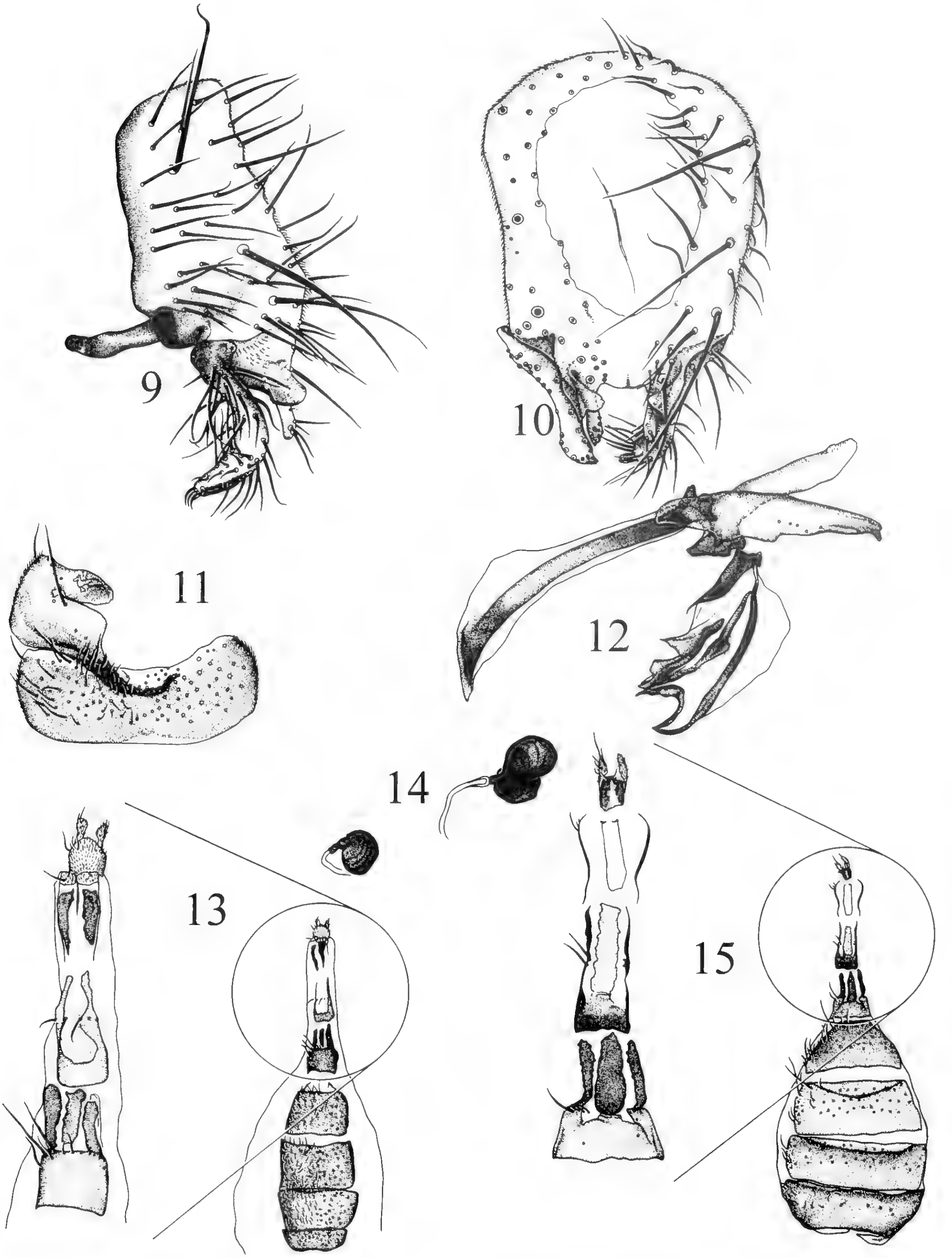
Limomyza archiptera Marshall, new species

(Figs. 1–4, 6)

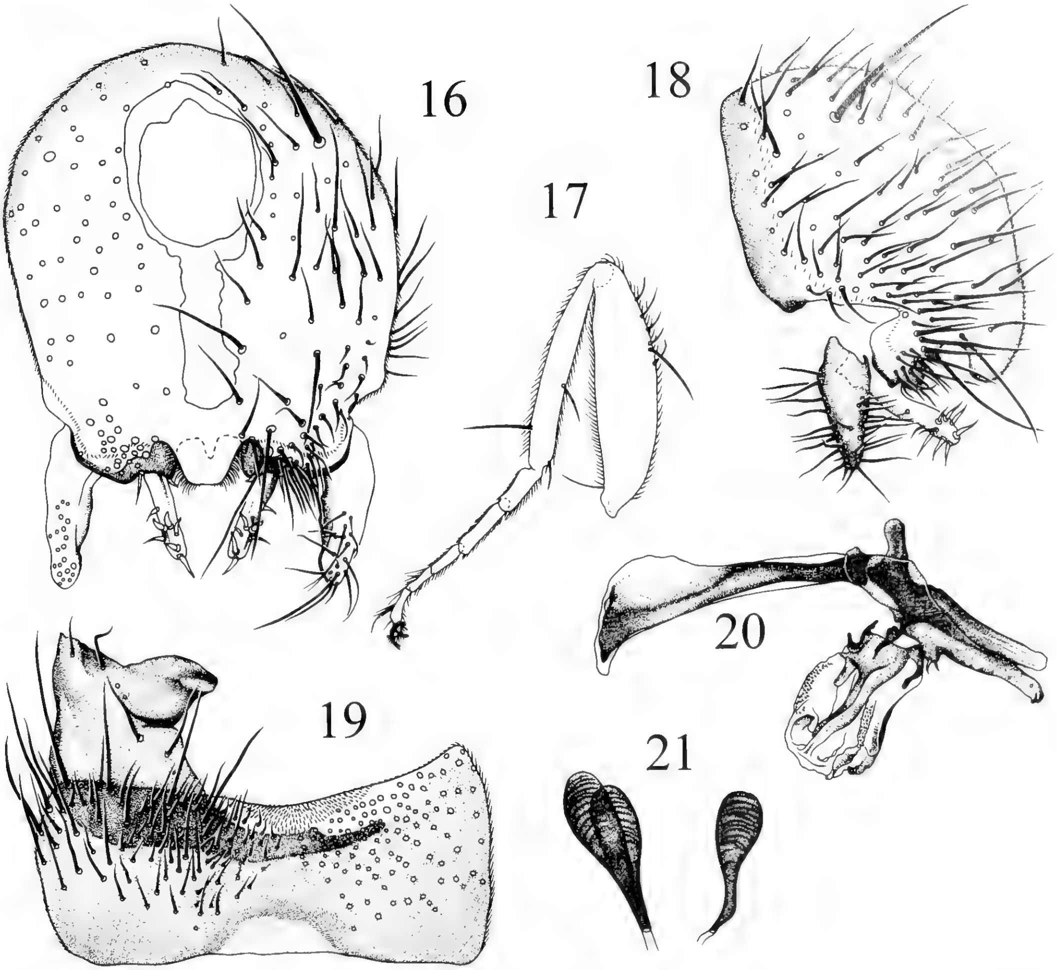
Body length ca. 3.0 mm; body Color black to dark reddish brown; tarsi, apices of tibiae and halters pale. Interfrontal bristles in 4 long, equal pairs; a row of 2–3 inclinate inner orbital setulae present midway between orbital and interfrontal areas, uppermost setula at level of lower orbital bristle. Face deeply concave, upper half of face silvery pruinose. Eye 2.1× genal height; gena shining anterodorsally, silvery pruinose posteriorly and ventrally, pruinose area with a large anterior bristle and several setulae. Katepisternum with two large dorsal bristles, posterior bristle twice as long as anterior. Acrostichal bristles long, in 8–10 rows between dorsocentral areas. Wing with R2+3 conspicuously but gradually bent at basal third; second costal sector 1.2× length of third; distance between crossveins r-m and dm-cu 1.4× length of dm-cu; alula narrow.

Male abdomen: Epandrium densely setose, with long dorsolateral and posteroventral bristles. Subanal plate broad, posterior part with conspicuous, setose medial ventral lobes (subcerci) with one bristle proximally, distally with 3 posteromedial bristles and 4–5 smaller medial setae; epandrial lobes overlapping subcerci basally and distally. Surstylus elongate, narrow base articulated with epandrium and broad hypandrial arm; anteriorly curved at ⅔, distal part dark with dense row of 6–8 stout, dark bristles, row shorter than maximum surstylar width.

Holotype (♂, CNC) and 13 Paratypes (4 ♂, 9 ♀, GUE): MEXICO. GUERRERO, 4 mi W Mazatlan, 4800′, 30.viii–5.ix.1971,



Figs. 9–15. *Limomyza cavernicola*. 9, Male terminalia, left lateral. 10, Male terminalia, posterior. 11, sternites 5–7, male. 12, Phallus and associated structures. 13, Female abdomen, ventral. 14, spermathecae. 15, Female abdomen, dorsal.



Figs. 16–21. 16–20, *Limomyza hirta,* male. 16, Terminalia, posterior. 17, Hind leg, left. 18, Terminalia, left, hypandrium removed. 19, Sternites 5–7. 20, Phallus and associated structures. 21, *L. sharkeyi,* spermathecae.

Oak, tropical deciduous forest, human dung, A. Newton.

Other paratypes: MEXICO. MEXICO. 1 mi E Ixtapan de la Sal, 6200′, km 78, 31.viii–6.ix.1971, tropical deciduous forest, dung trap, A. Newton (1 ♂, 1 ♀, GUE).

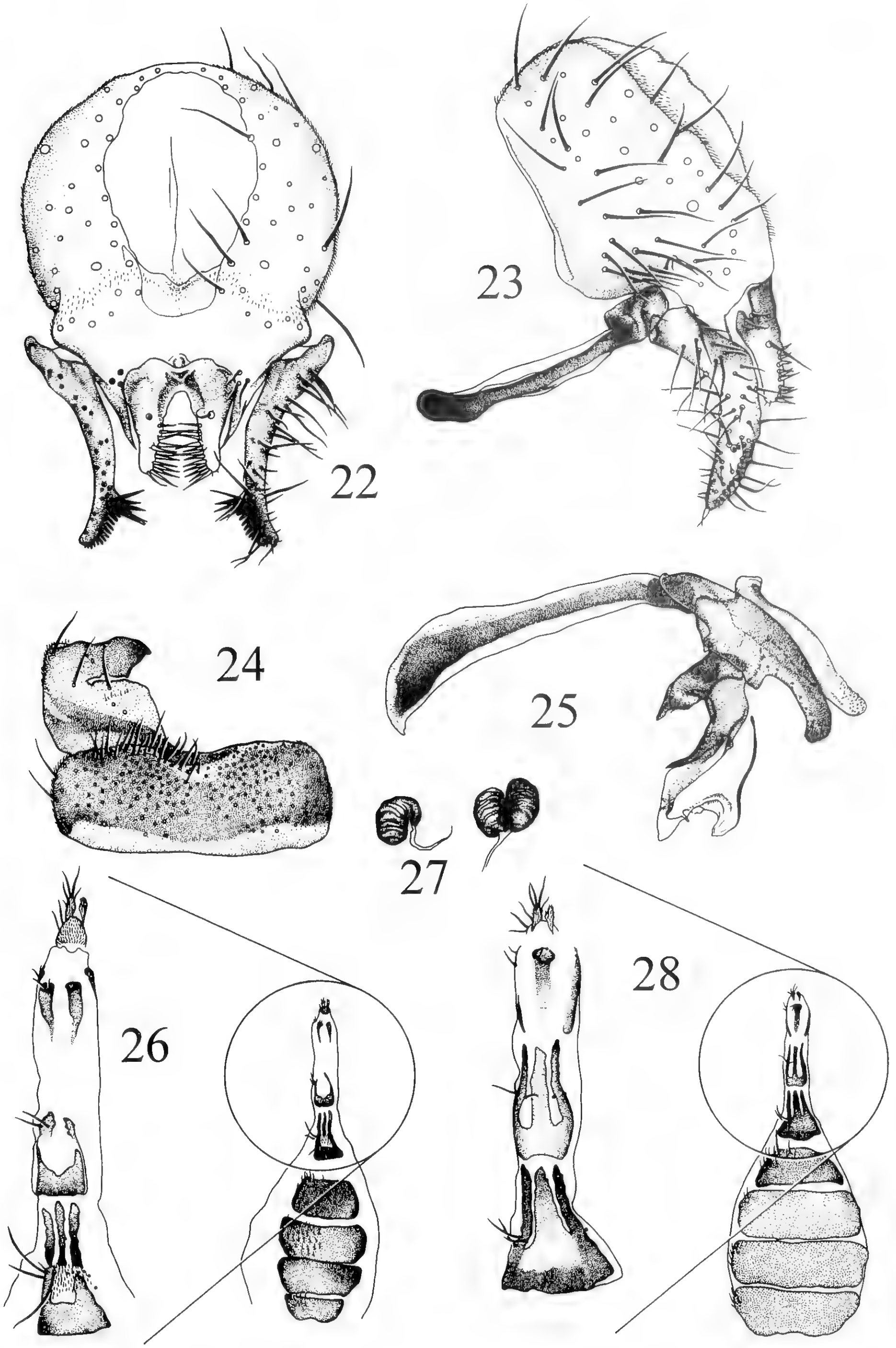
Etymology: The name *archiptera* refers to the primitive wing venation of the genus as a whole.

Comments: Limomyza archiptera is externally similar to *Limomyza venia,* differing primarily in features of the male genitalia. The surstyli of these species are distinctly different.

Limomyza cavernicola Marshall, new species

(Figs. 5, 7, 9–12)

Body length ca. 3.0 mm; body Color black to dark reddish brown; tarsi, apices of tibiae and halters pale. Interfrontal bristles in 4–5 long, equal pairs; a row of 3–4 inclinate inner orbital setulae present midway between orbital and interfrontal strips, uppermost setula at level of lower orbital bristle. Face deeply concave, upper half silvery pruinose. Eye 1.6× genal height; gena shining anterodorsally, silvery pruinose anteroventrally, pruinose area with a large an-



Figs. 22–28. *Limomyza venia.* 22, Male terminalia, posterior. 23, Male terminalia, left lateral. 24, Sternites 5–7, male. 25, Phallus and associated structures. 26, Female abdomen, ventral. 27, Spermathecae. 28, Female abdomen, dorsal.

terior bristle and several setulae. Katepisternum with two large dorsal bristles, posterior bristle twice as long as anterior. Acrostichal setulae in about 8–10 rows between dorsocentral areas. Wing with R2+3 sinuate, gradually curved up to costa near apex, second costal sector 1.7× length of third; distance between r-m and dm-cu 1.6× length of dm-cu; alula narrow.

Male abdomen: Epandrium densely setose, with long dorsolateral and posteroventral bristles. Subanal plate broad, posterior part with conspicuous, setose ventral lobes (subcerci) medially, epandrial lobes ventrally rounded, pale, basally overlapping subcercus; subcercus with 1 posterior bristle basally, distally with 3 posterodorsal bristles and a row of ca. 9 medial setae. Surstylus gradually curved anteriorly, distal part broad, with inner row of 13–14 stout, dark bristles, row ca 1.5 times as long as maximum surstylar width.

Holotype (♂, CNC): UNITED STATES. KENTUCKY. Edmonson Co., Mammoth Cave National Park, Running Br., 17–25.vi.1973, forest dung trap, S. Peck.

Paratypes: UNITED STATES. COLORADO. Larimer Co., 5,8,22.viii,30.ix.1996, S. Fitzgerald (8 ♂, 4 ♀, CSU). MISSOURI. Texas Co., 10.5 mi NW Licking, unnamed cave, 14.vi.1989, J.E. Gardner (3 ♂, 3 ♀, GUE); OKLAHOMA. Caddo Co., 0.5 mi. S. Hinton, Redrock Canyon State Park, 2–3.viii.1984, dung trap, B.V. Brown (1 ♂, GUE); Murray Co., Chickasaw National Recreation Area, 24.v.1991, J.E. Swann (1 ♂, GUE).

Etymology: The specific name refers to the association of *L. cavernicola* with caves.

Comments: Limomyza cavernicola is externally very similar to *Limomyza venia* and *Limomyza archiptera.* These species can be most reliably separated on the basis of the surstylus, but *L. cavernicola* also differs from *L. venia* and *L. archiptera* in having relatively small eyes, presumably associated with its hypogean habits. *Limomyza hirta,* a species of unknown biology which is easily distinguished from *L. cavernicola* by characters given in the key, also has very small eyes.

***Limomyza hirta* Marshall, new species**

(Figs. 16–20)

Body length ca. 5.0 mm; body Color black to dark reddish brown; antennae and most of pleuron reddish. Interfrontal bristles in 6-7 long, equal pairs; 2 rows of inclinate inner orbital setulae present midway between lower orbital and interfrontal bristles, inner row of *ca* 8 bristles extending up to level of ocellar bristle. Postocellar bristles convergent but equally long divergent postocular bristles present immediately behind postocellar bristles (the postocular bristles form a dense double or triple row behind the eye then extend across the back of the head as a sparse single row). Face deeply concave, pruinose; lateral margin of face and clypeus black. Eye 0.9× genal height; gena entirely pruinose, with a large anterior bristle and several setulae forming 4 rows on ventral half. Katepisternum with a large posterodorsal bristle and 2 very small anterodorsal bristles less than ⅓ as long as posterodorsal bristle. Upper surface of mid tibia with a row of anterior bristles paired with the usual anterodorsal bristles on the proximal half of the tibia. Acrostichal setulae long, in about 15 rows between dorsocentral areas. Wing with R2+3 conspicuously but gradually bent at basal third; second costal sector 2.2× length of third costal sector; distance between r-m and dm-cu 2.6× length of dm-cu.

Male abdomen: Epandrium densely setose, with long dorsolateral bristles. Subanal plate very broad, posterior part with a prominent, microsetulose median process; subepandrial sclerite with a smaller, bare, median process. Posterolateral corners of epandrium forming subquadrate, setose lobes (epandrial lobes): narrow posteroventral lobes (subcerci) overlapped by epandrial lobes, bent posteriorly, parallel sided, distally rounded with *ca* 8 bristles. Surstylus simple, elongate-triangular, with long anterior bristles. Gonostylus narrow and gradually tapering distally, apex blunt, bicarinate.

Holotype (♂, CNC): MEXICO. DURANGO. 10 mi W El Salto, 13.vii.1964, H.F. Howden.

Etymology: The specific name refers to the hirsute appearance of this large, distinctive species.

Comments: Limomyza hirta can be easily separated from congeners by the double row of postocular bristles, the extra row of anterior mid tibial bristles, the large size, the distinctive wing venation with a very long second costal sector, or by the surstylus which lacks the apical comb row characteristic of congeners.

Limomyza sharkeyi **Marshall, new species**

(Fig. 21)

Body length ca. 4.0 mm; body Color black to dark reddish brown; face and lower frons reddish, antennae and tarsomeres pale, orange; halter very pale. Interfrontal bristles in 4 long, equal pairs; 2 rows of inclinate inner orbital setulae present midway between lower orbital and interfrontal bristles, inner row of *ca* 6 bristles extending up to level of ocellar bristle. Postocellar bristles convergent. Postocular bristles in a dense single row behind the eye and a double row above the eye. Face slightly concave, pruinose on upper half; lateral margin of face and clypeus brown. Eye 2.0× genal height; gena silvery pruinose on lower half, upper half shining except for small posterodorsal pruinose area, with a large anterior bristle and several setulae forming 4 rows on ventral half. Katepisternum with a large posterodorsal bristle and an anterodorsal bristle ½ as long as posterodorsal bristle. Upper surface of mid tibia with small proximal anterodorsal and posterodorsal bristles in addition to the usual 5 anterodorsal and 4 posterodorsal bristles, and one small anterior bristle at middle. Acrostichal setulae long, in about 10 rows between dorsocentral areas. Wing with R2+3 conspicuously but gradually bent in basal third; second costal sector 1.5× length of third; distance between crossveins r-m and dm-cu twice as long as length of dm-cu; alula of medium width. Spermathecae elongate, with long straight bases in contrast with the short, curved bases of known congeneric females.

Holotype (♀, CNC): GUATEMALA. SAN MARCOS. San Antonio, 8000′, Sacatepequez, 29.ix.1987, M. Sharkey.

Paratype: MEXICO. CHIAPAS, Municipio El Porvenir, between El Porvenir and Siltepec, N. Slope Cerro Male, 2134–743 m, 19-ix.1976, D.E. and J.A. Breedlove (1 ♀, CAS).

Etymology: This species is named after Mike Sharkey, who has generously allowed me to study the flies from his insect trap catches.

Comments: Although it is generally undesirable to describe species of Sphaeroceridae from females only, these large *Limomyza* specimens are obviously different from all congeners. The chaetotaxy of the mid tibia, size, spermathecae, pruinosity of the gena, and inner orbital bristles all appear to be diagnostic, although the spermathecae are unknown for one congener (*L. hirta*).

Limomyza venia **Marshall, new species**

(Figs. 8, 22–28)

Body length ca. 3.0 mm; body color black to dark reddish brown; tarsi, apices of tibiae and halters pale. Interfrontal bristles in 4–5 long, equal pairs; a row of 3–4 inclinate inner orbital setulae present midway between orbital and interfrontal areas; uppermost setula at level of lower orbital bristle. Face deeply concave, upper half of face silvery pollinose. Eye 2.0× genal height; gena shining anterodorsally, silvery pruinose anteroventrally, pruinose area with a large anterior bristle and several setulae. Katepisternum with two large dorsal bristles, posterior bristle twice as long as anterior. Acrostichal setulae in about 8–10 rows between dorsocentral areas. Wing with R2+3 sharply bent up at basal third;

second costal sector 1.3–1.4× as long as third; distance between crossviens r-m and dm-cu 1.2–1.3× length of dm-cu; alula narrow.

Male abdomen: Epandrium densely setose, with long dorsolateral and posteroventral bristles. Subanal plate broad, posterior part with conspicuous, setose ventral lobes (subcerci) medially, epandrial lobes ventrally narrow, acute, pale; subcercus with 1 posterior bristle basally, distally with 3 posterodorsal bristles and a row of ca. 9 medial setae; epandrial lobe not conspicuously overlapping subcercus basally. Surstylus elongate, sharply bent at ⅓, distal part with inner row of 13–14 stout, dark bristles, row over twice as long as maximum surstylar width.

Holotype (♂, CNC) and 90 Paratypes (48 ♂, 42 ♀, GUE, FLD): MEXICO. MEXICO. 1 mi NE Tenancingo, 7100′, 31.viii–6.ix.1971, Oak -Pine, human dung trap, A. Newton.

Other paratypes: MEXICO. MORELOS. 4 mi W Tres Cumbres, 9000′, 29.viii–4.ix.1971, Oak, human dung trap, A. Newton (6 ♂, 3 ♀, GUE).

Etymology: The name of this species is to be considered an arbitrary combination of letters.

ACKNOWLEDGMENTS

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A NEW SPECIES OF NEARCTIC *PERLESTA* (PLECOPTERA: PERLIDAE) FROM VIRGINIA

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Abstract.—A new species of stonefly from southwestern Virginia is added to the Nearctic *Perlesta,* which presently includes 14 species. **Perlesta teaysia, new species**, is described from the adult male, adult female, egg, and mature nymph. Diagnostic features are supported by illustrations and SEM photomicrographs.

Key Words: *Perlesta,* new species, North America, Nearctic Region, Virginia

Stark (1989) revised and keyed 12 species in the *Perlesta placida* (Hagen) complex. Poulton and Stewart (1991) and Stark and Rhodes (1997) have added two additional species to the Nearctic list.

A distinctive new species of *Perlesta* was reared by the senior author in 1979. However, not until recently did the adult male become available with the extruded penis tube and sac for a comparative description. The new species is related to *P. frisoni* Banks in sharing the characters of the penis lacking a caecum, and tergum ten with two elevated sensilla basiconica patches.

The Holotype will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). Paratypes will be deposited in the following museums and individual collections: Bill P. Stark, Clinton, Mississippi (BPS), C. P. Gillette Museum of Arthropod Diversity, Colorado State University (CSU), Monte L. Bean Museum, Brigham Young University (BYU), and Ralph F. Kirchner (RFK, Huntington, West Virginia).

Perlesta teaysia Kirchner and Kondratieff, new species

(Figs. 1–10)

Male.—Forewing length 7.5–8.5 mm. General color light yellow in life, pale yellow in alcohol. Head with a brown patch over ocellar triangle, with a light brown spot near anterior margin (Fig. 1). Pronotum brown. Wings pale, costal margin of forewing pale. Femora with dorsal margin brown. Tergum 10 with two elevated patches of 19 to 21 brown sensilla basiconica, separated along mid-line of tergum (Figs. 2, 8, 9). Paraprocts straight, moderately long without a tooth (Figs. 3, 4). Penis tube and sac long and slender; dorsal patch pale and inconspicuous; caecum absent (Fig. 5).

Female.—Forewing length 10–11 mm. Color pattern similar to male. Subgenital plate with a prominent U-shaped notch, outer lobes rounded (Fig. 6).

Egg.—Length ca. 0.37 mm, width ca. 0.29. Collar short, ca. 0.025 high, ca. 0.073 wide. Chorion smooth (Fig. 10).

Nymph.—Body length 8–10 mm. Gen-

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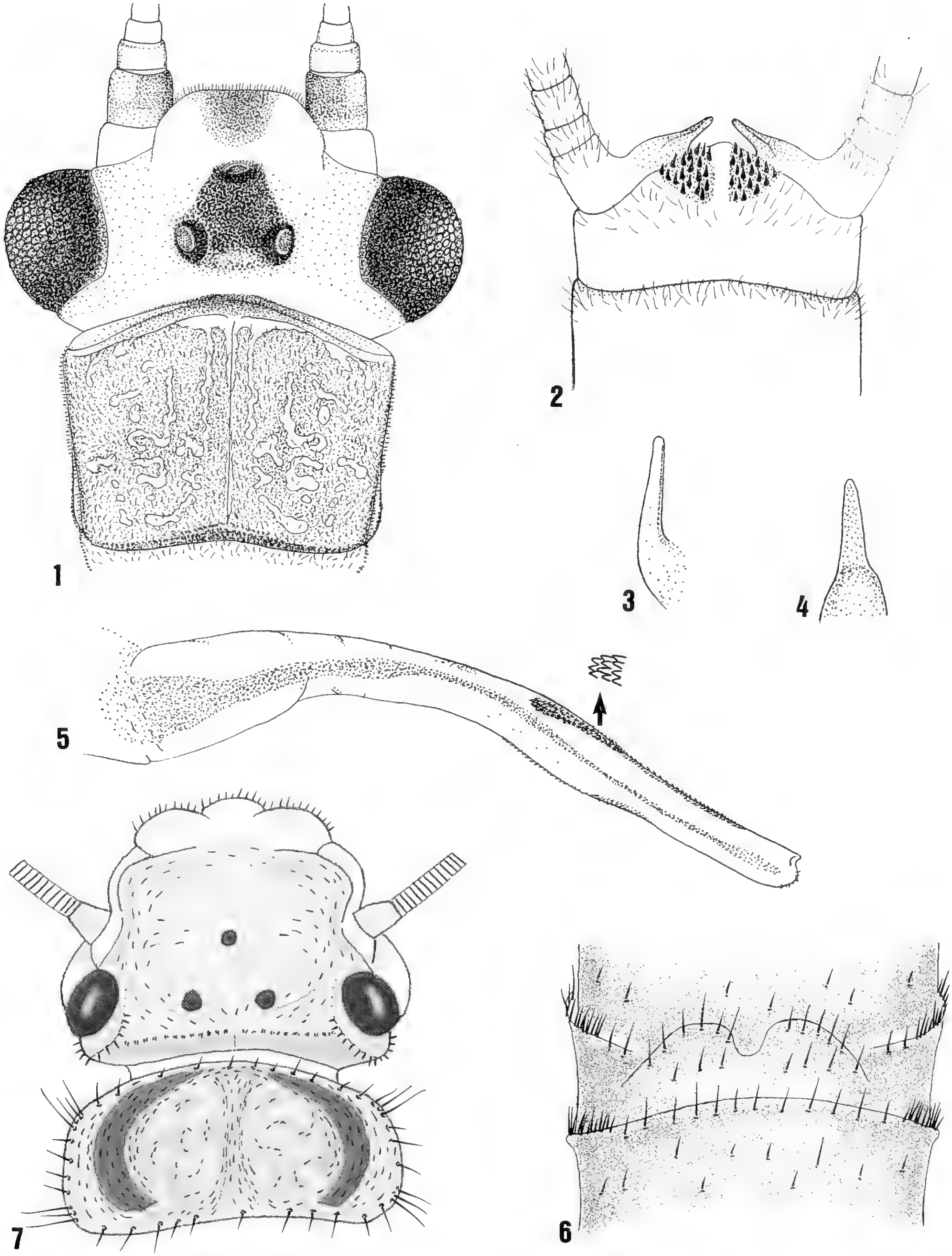
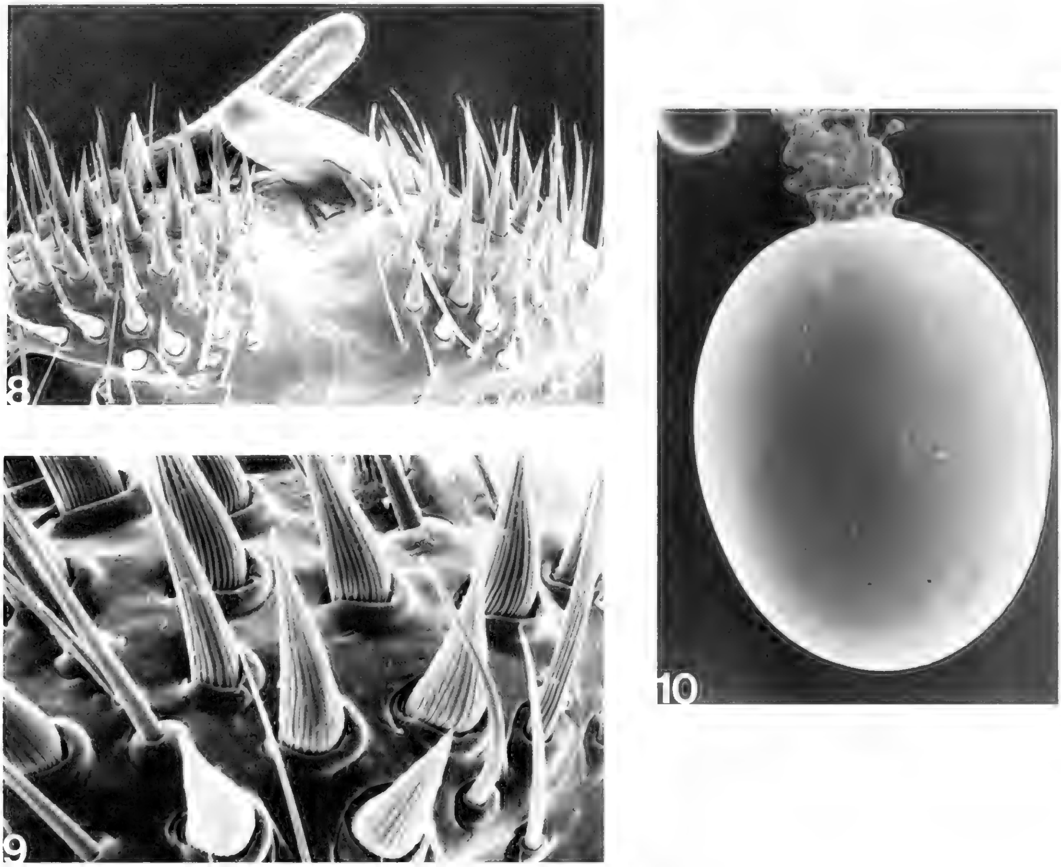
[1] The views of the author do not purport to reflect the position of the Department of the Army or the Department of Defense.



Figs. 1–7. *Perlesta teaysia.* 1, Adult head and pronotum. 2, Male terminalia, dorsal. 3, Paraproct, lateral. 4, Paraproct, caudal. 5, Penis, lateral (arrow indicates penis armature). 6, Female subgenital plate, ventral. 7, Nymphal head and pronotum.



Figs. 8–10. *Perlesta teaysia,* scanning electron photomicrographs. 8, Male terminalia, dorsal, 372×. 9, Sensilla basiconica, 10th tergum, male, 1260×. 10, Egg, 238×.

eral color yellow brown; body clothed with appressed brown hairs. Head without transverse dark band crossing ocelli (Fig. 7). Occipital setal row approaches ecdysial suture. Pronotal disk with "parentheses-like" dark brown areas (Fig. 7). Abdominal terga yellow brown; intercalary bristles without dark sockets.

Types.—Holotype ♂, Virginia: Wythe County, Reed Creek of New River, U.S. Route 11 bridge, 3.2 km West of Wytheville, 23 July 1996, R. F. Kirchner and B. C. Kondratieff (USNM). Paratypes: same data as holotype, 6 ♂, 17 ♀ (CSU); same data as holotype except, 11 July 1975, R. F. Kirchner 1 ♂, 7 ♀ (RFK); same data as holotype except 21 ♂, 5 ♀, (reared), 7 July 1979, R. F. Kirchner (BPS, BYU, RFK).

Additional material examined.—13 nymphs, same data as holotype except, 7 July 1979, R. F. Kirchner.

Diagnosis.—The adult male of *P. teaysia* will key to couplet 3 in Stark (1989), appearing most similar to *P. frisoni.* Both species have conspicuous elevated patches of sensilla basiconica on tergum 10 (Figs. 2, 8, 9). However, the paraprocts of *P. teaysia* are longer and lack a mesal tooth (Figs. 3, 4; see Stark 1989, Fig. 52). The adult female subgenital plate of *P. frisoni* is triangular in shape and has a V-shaped notch (Stark 1989), while the subgenital plate of *P. teaysia* is rounded in outline and has a U-shaped notch (Fig. 6).

Etymology.—The specific epithet refers to the ancient Teays River system of the

Pliocene. The present Kanawha-New River drainage in North Carolina, Virginia, and West Virginia is considered as a remnant of the upper Teays River. Reed Creek flows into the New River 22 km East of Wytheville, Virginia.

Remarks.—Stark (1989) reported *P. decipiens* (Walsh), *P. frisoni* and *P. placida* from Virginia. The distribution of *P. frisoni* is apparently limited to the older Appalachians Mountains (Blue Ridge Physiographic Province) of North Carolina, Tennessee and Virginia. The following species of stoneflies have been collected at the type locality: *Allocapnia granulata* (Claassen), *A. loshada* Ricker, *A. nivicola* (Fitch), *A. rickeri* Frison, *Prostoia completa* (Walker), *Strophopteryx fasciata* (Burmeister), *Taeniopteryx burksi* Ricker and Ross, *T. maura* (Pictet), *Acroneuria abnormis* (Newman), *A. filicis* Frison, *Neoperla clymene* (Newman), *N. occipitalis* (Pictet), *Paragnetina media* (Walker), *Diploperla morgani* Kondratieff and Voshell, *Helopicus subvarians* (Banks), and *Isoperla signata* (Banks).

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ADDITIONAL NOTES ON NEARCTIC *BIBIO* GEOFFROY (DIPTERA: BIBIONIDAE)

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Abstract.—Six new synonyms of Nearctic *Bibio* are presented and a former, subspecific synonym is raised to specific status. New synonyms are: *Bibio nigripilus* Loew = *B. abbreviatus* Loew; *B. painteri* James and *B. knowltoni* Hardy = *B. alexanderi* James; *B. nigrifemoratus* Hardy = *B. atripilosus* James; *B. imparalis* Hardy = *B. fluginatus* Hardy; *B. utahensis* Hardy = *B. similis* James. Variation within these species is discussed, and diagnoses and distribution are given for each. *Bibio xanthopus palliatus* McAtee is raised to specific status, and the morphological similarity of this species to *B. xanthopus* Wiedemann is discussed.

Key Words: *Bibio,* Nearctic, synonymy

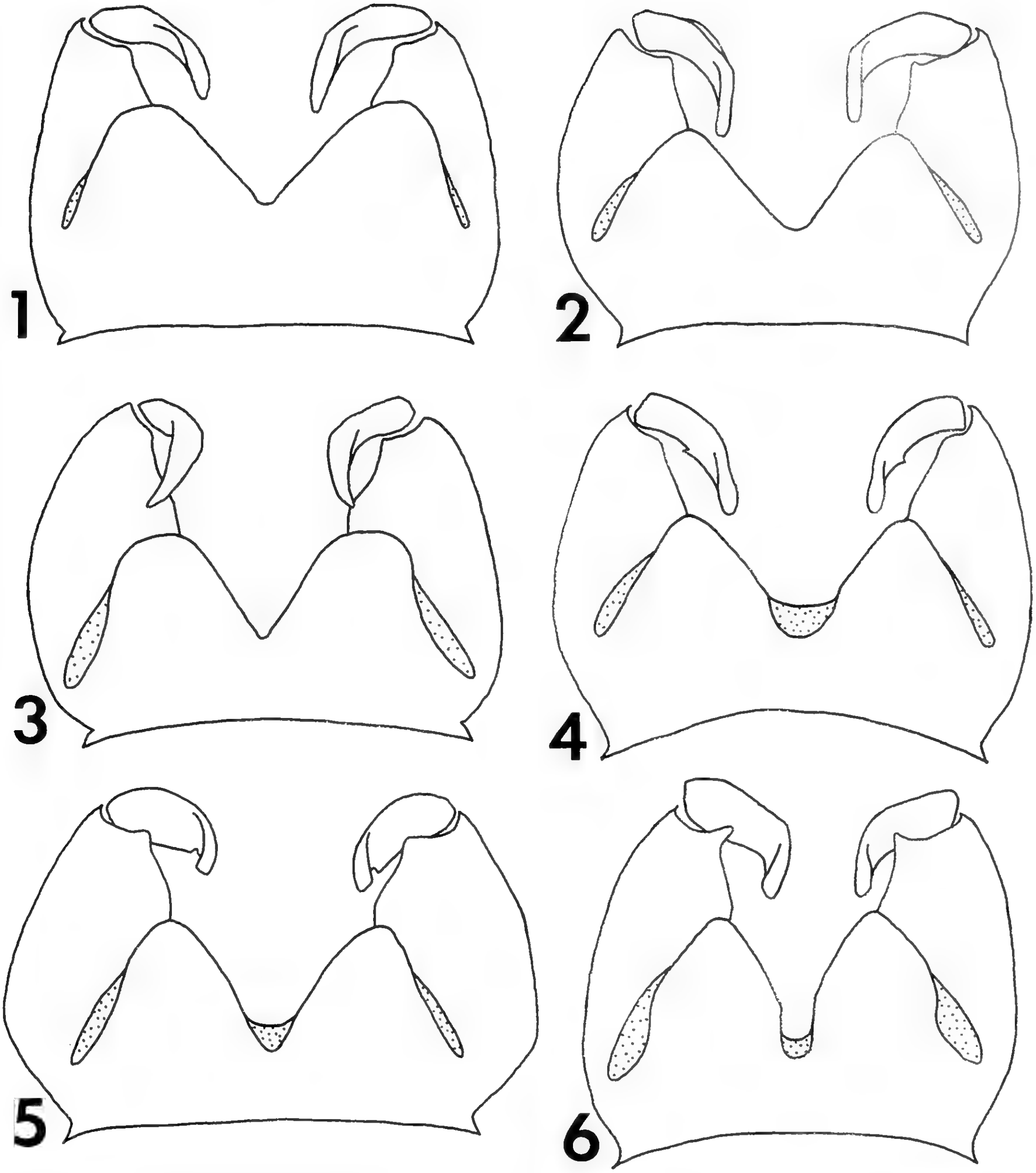
Hardy (1945) provided the most recent revision of the Nearctic species of *Bibio*. Presently, 43 species are recognized (Hardy 1981, Fitzgerald 1996, Fitzgerald and Skartveit, in press).

A number of species of *Bibio* are based soley on leg color and thoracic pile color, both which can be useful in combination with other characters. These characters often exhibit much intraspecific variation. The use of male terminalia, the number of sensilla of the hind tibia, relative length of the anterior spur of the fore tibia, shape of the hind tibial spur, shape and length of the hind basitarsus, length of the basal portion of Rs vein relative to r-m crossvein, and pigmentation of the posterior veins, in combination with leg and pile color, has allowed better resolution of intraspecific variation, thus resulting in the synonyms established in this paper.

The approximate number of sensilla of the hind tibia of males and some females is given for the first time for the Nearctic species discussed. Although ranges of sensilla of some species overlap broadly, others do not, and so can provide an additional character to aid in species separation.

Sex ratio in several Palearctic *Bibio* species has been shown to be male biased (more males/female) (Skartveit 1993). Because males are more commonly collected and often provide more characters for specific separation, female records are included (under material examined for each species) only when associated with males or for species in which females are distinctive. Females of a number of species are at present, difficult, or not possible to distinguish.

Terminology follows McAlpine (1981). In diagnoses, the number of sensilla of the hind tibia is given as a range where N = number of hind tibia examined. Acronyms for specimen depositories used in this study are as follows: American Museum of Natural History (AMNH); Monte L. Bean Life Science Museum, Brigham Young University (BYU); California Academy of Sciences (CAS); Canadian National Collection, Ottawa (CNC); C. P. Gillette Museum



Figs. 1–6. Male postabdomen, dorsal view. 1, *Bibio abbreviatus*. 2, *B. fraternus*. 3, *B. alexanderi*. 4, *B. fluginatus*. 5, *B. palliatus*. 6, *B. xanthopus*.

of Arthropod Diversity, Colorado State University (CSUFC); University of Colorado (UColB); Museum of Comparative Zoology, Harvard (MCZ); New York State Museum, Albany (NYSM); Snow Entomological Museum, University of Kansas (UKaL); Texas A & M University (TAMU); University of Minnesota (UMSP); National Museum of Natural History, Smithsonian Institution (USNM).

Bibio abbreviatus Loew
(Fig. 1)

Bibio abbreviatus Loew 1864: 54. Syntype male (MCZ), USA: District of Columbia, Osten Sacken; examined.

Bibio nigripilus Loew 1864: 55. Syntype male (MCZ), CANADA: Winnipeg, Kennicot; examined. **New Synonym.**

Bibio lucens Hardy 1937: 204. Holotype male (UMSP), CANADA: Ontario, Miners Bay, 26 May 1929, G.S. Walley. (synonymized with *B. nigripilus* by Hardy 1945).

Discussion.—*Bibio abbreviatus* and *B. nigripilus* have historically been separated by the yellow thoracic pile in *B. abbreviatus* and black thoracic pile in *B. nigripilus* (Loew 1864, Hardy 1945, Hardy 1958). Hardy (1958) stated, "I am very skeptical of this character and doubt that it alone would be reliable." Examination of male terminalia of syntypes of both species has indicated that *B. abbreviatus* and *B. nigripilus* are conspecific. Thoracic pile color may be yellow, black or intermixed.

Diagnosis.—*Bibio abbreviatus* is most similar to *B. fraternus* Loew with which it is seasonally and geographically sympatric. However, males of *B. abbreviatus* can be separated from *B. fraternus* by the shorter hind basitarsus (see Hardy 1958: 30, Figs. 9b and 32, Fig. 12a), and the gonostylus slightly flattened (Fig. 1), rather than digitate (Fig. 2). Males of *B. abbreviatus* can be distinguished from other Nearctic *Bibio* by the combination of the following characters: Legs predominantly yellow orange; anterior spur of fore tibia three-quarters to subequal length of posterior spine; posterior basitarsus not swollen; posterior veins concolorous with membrane; hind tibial spurs slender (rather than broadly flattened); gonostylus slightly flattened (Fig. 1); epandrial cleft broadly V-shaped extending about one-half length of epandrium (Fig. 1); sensilla of hind tibia number approximately 20–200 (average = 108, N = 22).

Females of *B. abbreviatus* are most similar to *B. fraternus* but can be distinguished by the black thorax in *B. abbreviatus* and the orange yellow thorax in *B. fraternus*. Although females of *B. fraternus* usually have the thorax distinctly orange yellow, the thorax is occasionally nearly black with only an orange tinge, and should not be mistaken for *B. abbreviatus*. Females of *B. abbreviatus* can also be distinguished by the following combination of characters: Color of legs, length of anterior spur of fore tibia, and hind tibial spurs as in male; posterior veins pigmented brown; dorsum of thorax black; sensilla of hind tibia number approximately 34–89 (N = 4).

Biology.—The flight period of this species is April and May with a few records from June. One record (UMSP) from Minnesota in October is probably incorrect. Adults have been swept from winter wheat in Indiana. Strickland (1916) reported the larvae as a celery pest and provided details of larval feeding habits and biology.

Distribution.—As in Hardy (1958), widespread in eastern United States and southeastern Canada: Ontario and Quebec, south to Georgia, Arkansas, west to South Dakota, Kansas, and Texas.

Material examined.—In addition to the types, the following material was examined: CANADA: ONTARIO: Lockburn, 18 May 1926, 2 ♂ 1 ♀ (one pair in copula) (CSUFC); USA: ARKANSAS: Crawford Co., 4 April 1927, 2 ♂ (CSUFC); KANSAS: Douglas Co., 16 April 1946, R.H. Beamer, 3 ♂ (UKaL); Gove Co., 20 April 1930, 1 ♂ 1 ♀ (CSUFC); Reno Co., Hutchinson, 2 May 1948, R.H. Beamer, 4 ♂ (UKaL); INDIANA: Tippecanoe Co., Lafayette, swept from winter wheat, 2 May, 3 ♂ (USNM); MAINE: Somerset Co., Hwy 201, 12 June 1993, Kondratieff & Baumann, 1 ♂ 1 ♀ (in copula) (CSUFC); MARYLAND: Plummers Island, 26 April 1923, H.S. Barber, 1 ♂ (USNM); MINNESOTA: Cook Co., Min. F.S., Hovland, Malaise trap, 10 October 1973, 1 ♂ (UMSP); Pine Co., Mine dump, north bank Snake River, 4 miles east of Pine City, 19 May 1951, 1 ♂ (UMSP); Pipestone Co., Pipestone National Monument, Malaise trap, 30 May 1973, 1 ♂ (UMSP); MISSOURI: May, C.V. Riley, 1 ♂ (BYU); NEW YORK: Hamilton Co.: 6 miles east of Indian Lake, 45°10′14″, 18 May 1977, 1 ♂ (CSUFC); 10 miles east of Indian Lake, 43.45.30–74.10.14, 555 m, T.L. McCabe: 25 May 1980, 1 ♂ (NYSM); 27 May 1980, 1 ♂ (NYSM); 18 May 1977, 1 ♂ (NYSM); OHIO: Fairfield Co., 2 May 1931, J. Pattan, 1 ♂ (UMSP); PENNSYLVANIA: Centre Co., State College, 1 May 1910, 1 ♂ (USNM); TEXAS: Bandera Co., Lost Maples State Park, 22 March 1985, Kovarik, Jones & Haack, 12 ♂ 1 ♀ (TAMU); VIRGINIA: Fauquier Co., Warrenton, 5 May 1928, L.C. Woodruff, 4 ♂ (UKaL); Fairfax Co., Great Falls, 23 April 1919, 1 ♂ (USNM); Montgomery Co., near Toms Creek, Route 655, 25 April 1979, B. Kondratieff, 1 ♂ (CSUFC).

Bibio alexanderi James
(Fig. 3)

Bibio alexanderi James 1936: 1. Holotype female (AMNH), USA: Colorado: Boulder Creek bottoms near Valmont, 24 April 1934, E. Gordon Alexander; examined.

Bibio painteri James 1936: 2. Holotype female, allotype male (same pin) (AMNH), USA: Kansas, Manhattan, 19 April 1932, R.H. Painter; examined. **New Synonym.**

Bibio knowltoni Hardy 1937: 202. Holotype male (BYU), USA: Utah, Granger, on *Lepidium,* 29 April 1931, G.F. Knowlton; not examined. **New Synonym.**

Bibio knowltoni var. *paltidus* Hardy 1937: 203. Holotype male (BYU), USA: Utah, Provo, 8 May 1937, D.E. Hardy. (synonymized with *B. knowltoni* by Hardy 1965).

Discussion.—The holotype female, allotype male (AMNH) and two female paratypes (CSUFC) of *B. alexanderi,* the holotype female, allotype male (AMNH), and five paratypes (two pair in copula) (CSUFC) of *B. painteri,* four male paratypes (USNM) of *B. knowltoni,* and six male paratypes (USNM) of *B. k. paltidus* were examined and found to be conspecific. In contrast to the rounded apex of the gonostylus in many Nearctic *Bibio,* the gonostylus of *B. alexanderi* is apically acute in dorsal view (Fig. 3). Previously, males of *B. alexanderi, B. painteri* and *B. knowltoni* were separated by minor differences in leg color and pile color of the eyes and tibiae (James 1936, Hardy 1945). Females were separated by the entirely orange yellow dorsum of the thorax in *B. alexanderi,* with black markings in *B. painteri,* and entirely black in *B. knowltoni.* Individual females from single populations can exhibit this range of thoracic color.

Hardy (1945) distinguished *B. carri* Curran from *B. alexanderi* by the position of a transverse depression separating the upper and lower portion of the compound eye. In *B. carri* this depression is just below middle line, and in *B. alexanderi* it is near the lower one-fourth. A topotypic male of *B. carri* (CSUFC) has been examined and is similar to *B. alexanderi* in all respects, including male terminalia, with the exception of the position of the transverse depression on the eye. However, since the two species are apparently allopatric (*B. carri* known only from Alberta, Canada), and the unique position of the transverse depression of the eye in *B. carri* is not present in any populations of *B. alexanderi* examined, *B. alexanderi* and *B. carri* are recognized as distinct species.

Diagnosis.—Males of *B. alexanderi* are most similar to *B. carri,* but can be separated by the position of the transverse depression of the compound eye (see discussion). The most diagnostic character of *B. alexanderi* is the broadly flattened hind tibial spur which will distinguish both males and females from the similar *B. abbreviatus, B. xanthopus,* and *B. atripilosus.* Additional characters to distinguish males of *B. alexanderi* are: Legs predominantly yellow orange, sometimes with brown markings; anterior spur of fore tibia one-third to slightly over one-half length of posterior spine; hind basitarsus not swollen, shorter (less than four times as long as wide) than in *B. xanthopus* Wiedemann; hind tibial spurs broadly flattened and usually apically rounded; posterior veins darker than membrane; transverse depression separating the upper and lower portion of the compound eye near the lower one-fourth of the eye; gonostylus apically acute in dorsal view (Fig. 3); sensilla of hind tibia number approximately 34–78 (N = 33).

Females of *B. alexanderi* are diagnosed by the length of the anterior spur of the fore tibia and hind tibial spur as in the male; thoracic color ranges from black to orange yellow to orange yellow with black markings; sensilla of hind tibia number approximately 34–56 (N = 6).

Biology.—The flight period is March to early July, with most records from March and April. Pairs in copula have been taken in April in Arizona and Colorado. Adult collection records are from *Lindheimera texana* (Asteraceae) in Texas, and on *Medicago sativa* L. (alfalfa: Fabaceae), *Lepidium* sp. (Brassicaceae), and *Descurainia sophia* (L.) (Brassicaceae) in Utah. It was reported as a nuisance pest in Denver Co., Colorado from a bluegrass lawn in late April. The use of a sprinkler system apparently triggered a mass emergence of the flies (10–15 insects per blade of grass) (personal communication).

Distribution.—Southwestern United States: Arizona, California, Colorado, Kansas, New Mexico, Oklahoma, Texas, and Utah. Hardy (1945) listed *B. painteri* from Ohio.

Material examined.—In addition to the type material, the following material was examined: USA: ARIZONA: Gila Co., Globe, 5 April 1937, Parker, 3 ♂ 1 ♀ (one pair in copula) (USNM); Maricopa Co., Phoenix, 8 March 1945, F.H. Parker, 1 ♂ (USNM); CALIFORNIA: Los Angeles Co., Glendora, Dalton Canyon, 15 March 1929, E.G. Anderson, 1 ♂ (UMSP); COLORADO: Denver Co., Thorton, lawn, 26 April 1994, C. Wilson, 4 ♂ 3 ♀ (CSUFC); Yuma Co., Chief Creek, road CC N., 25 April 1993, S. Fitzgerald, 2 ♂ (CSUFC); KANSAS: Sedgwick Co., Wichita, 18 April 1917, 1 ♂ (USNM); NEW MEXICO: Dona Ana Co., Las Cruces, N.M.S.U., 13 March 1994, R. Durfee, 1 ♂ (CSUFC); OKLAHOMA: Alfalfa Co., 12 April 1931, 2 ♂ (AMNH); Cleveland Co., Norman, 13 March 1931, 9 ♂ 2 ♀ (AMNH); Stephens Co., Comanche, 12 April 1952, Michener, Beamers, Wille & LaBerge, 5 ♂ 2 ♀ (1 ♂ taken on *Lindheimera texana*) (UKaL); TEXAS: 12 March 1900, 1 ♂ 2 ♀ (USNM); Travis Co., Austin, 9 March 1900, 4 ♂ 4 ♀ (USNM); UTAH: Grand Co., Colorado River, highway 163 north of Moab, 23 April 1982, Baumann & Clark, 3 ♂ (in alcohol) (BYU); Washington Co.: North Fork Virgin River, Temple of Sinawara, Zion National Park, 30 March 1981, Baumann & Stranger, 3 ♂ (in alcohol) (BYU); Emerald Pools, Zion National Park, 8 April 1983, Baumann, 1 ♂ (in alcohol) (BYU); Utah Co., Provo, Environs., D.E. Hardy, 1 ♂ (BYU).

Bibio atripilosus James

Bibio atripilosus James 1936: 2. Holotype male (AMNH), USA: Colorado, Boulder, 5 May 1934, M.T. James; examined.

Bibio nigrifemoratus Hardy 1937: 206. Holotype male and allotype female (CNC), CANADA: British Columbia, Monte Lake, 13 May 1936, J.K. Jacob; examined. **New Synonym.**

Bibio nigrifemoratus var. *gilvus* Hardy 1937: 206. Holotype male (USNM), USA: Utah, Hyrum, 1 May 1937, G.F. Knowlton, F.C. Harmston; examined. (synonymized with *B. nigrifemoratus* by Hardy 1961).

Discussion.—The holotype (AMNH) and four male paratypes (CSUFC) of *B. atripilosus,* the holotype of *B. n. gilvus,* and the holotype, allotype (CNC) and six paratypes (BYU) of *B. nigrifemoratus* were examined and found to be conspecific. The shape of the gonostylus of the male is distinct from all other Nearctic *Bibio* (see Hardy 1961: 185, Fig. 6c). Characters historically used to separate *B. atripilosus* and *B. nigrife-*

moratus (Hardy 1945), such as thoracic pile color, wing length, and length of the anterior spur of the fore tibia, vary intraspecifically. *Bibio nigrifemoratus* was described with black pile, and *B. atripilosus* described with a wing length of 7 mm. In males of this species thoracic pile color ranges from yellow to black, the wing length ranges from 4–6 mm, and the length of the anterior spur of the fore tibia is one-fifth to one-third the length of the posterior spine.

Of the two paratypes of *B. nigrifemoratus* that Hardy (1937) listed from Kiger's Island, Oregon (Benton Co.), one has been examined. This specimen is not *B. nigrifemoratus,* but *B. similis* James, differing in the longer anterior spur of the fore tibia and the simple, digitate rather than uniquely shaped gonostylus (see Hardy 1961: 185, Fig. 6c). The second paratype specimen from Kiger's Island, Oregon is also probably *B. similis.*

Diagnosis.—Males of *B. atripilosus* are most similar to *B. xanthopus,* but can be distinguished by the unique shape of the gonostylus (see Hardy 1961: 185, Fig. 6c). Males can be distinguished from all other Nearctic *Bibio* by the following combination of characters: Anterior spur of fore tibia short, one-fifth to one-third length of posterior spine; hind basitarsus not swollen; posterior veins darker than membrane; hind tibial spurs slender (rather than broadly flattened); sensilla of hind tibia number approximately 15–50 (N = 13); gonostylus distinct (see Hardy 1961: 185, Fig. 6c).

Biology.—The flight period is April to June, with most records in April and May. Collections have been made at elevations of 610–1830 m.

Swarms of 5–15 males, 0.30–0.61 m off the ground, have been observed in an open ponderosa pine forest (elevation ≈ 1830 m) along the Front Range in northern Colorado. Swarms were generally oriented over rocks, and when clouds temporarily blocked direct sunlight, individuals would land on rocks or adjacent vegetation. With the return of direct sun, swarming would resume. Copulating pairs have been observed in April and May. In one case, two males attempted to copulate, and simultaneously displaced each other from one female.

Distribution.—Northwestern United States and extreme southwestern Canada: British Columbia, California, Colorado, Idaho, Montana, Utah, and Washington.

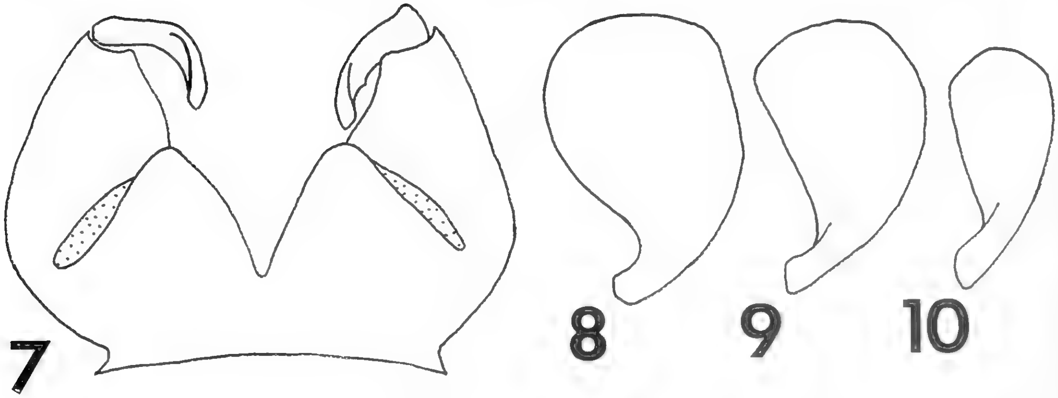
Material examined.—In addition to type material, the following material was examined: CANADA: BRITISH COLUMBIA: Robson, 26 May 1936, Foxlee, 2 ♂ (USNM); USA: CALIFORNIA: Cuyamaca, 17 May 1948, 1 ♂ (USNM); COLORADO: Boulder Co.: 5 May 1934, M.T. James, 1 ♂ (CSUFC); one mile southwest of Boulder, 6000 ft., 25 April 1963, U.N. Lanham, 3 ♂ (UColB); Boulder, 24 April 1971, U.N. Lanham, 3 ♂ (UColB); Larimer Co., Horsetooth Reservoir, ridge north of Spring Creek Dam, 24 April 1995, S. Fitzgerald & A. Foley, 25 ♂ 5 ♀ (two pairs in copula) (CSUFC); IDAHO: Boise Co., Warm Spring Creek junction South Fork Payette River, highway 21, 23 April 1984, Baumann & Nelson, 1 ♂ (BYU); UTAH: Carbon Co., Minnie Maude Creek junction Nine Mile Creek, 1 April 1978, Baumann & Winget, 1 ♂ (BYU); WASHINGTON: Stevens Co., Kettle Falls, 3 May 1912, 3 ♂ (USNM); Whitman Co.: Pullman, J.A. Hyslop, 25 ♂ (USNM); Pullman, 2000–2500 ft., 13 April 1991, P. McLellan, 1 ♂ (CSUFC).

Bibio fluginatus Hardy
(Fig. 4)

Bibio fluginatus Hardy 1937: 201. Holotype male (USNM), CANADA: British Columbia, Salmon Arm, 13 May 1933, Hugh Leech; examined.

Bibio imparalis Hardy 1959: 209. Holotype male (CAS), USA: California, Mariposa Co., Yosemite Valley, 21 May 1921, E.C. Van Dyke; not examined. **New Synonym.**

Discussion.—The descriptions of *B. fluginatus* and *B. imparalis* are nearly identi-



Figs. 7–10. Male postabdomen. 7, *Bibio similis,* dorsal view. 8–10, Right gonostylus, posterior view. 8, *B. palliatus.* 9, *B. xanthopus.* 10, *B. similis.*

cal. Neither relationships nor diagnostic characters were given by Hardy (1959). The male terminalia of the holotype male of *B. fluginatus* and a topotypic male paratype of *B. imparalis* (USNM) have been examined and are found to be conspecific. The holotype of *B. fluginatus* is missing the hind legs, which have important characters for species separation, but Hardy (1937) provided a good original description of the hind legs.

Diagnosis.—Males of this small species of *Bibio* are most similar to *B. atripilosus,* but can be distinguished by the simple digitate gonostylus rather than the uniquely shaped gonostylus of *B. atripilosus* (see Hardy 1961: 185, Fig. 6c). Males can also be distinguished by the following combination of characters: Legs yellow orange; anterior spur of fore tibia one-forth to one-third length of posterior spine; wing 4 mm, posterior veins darker than membrane; hind basitarsus slightly swollen; hind tibial spurs slender; antennal flagellum five segmented; sensilla of hind tibia number approximately 78–98 (N = 3); in dorsal view gonostylus broadly rounded apically (Fig. 4); epandrial cleft about two-thirds length epandrium, broadly V-shaped, usually with a U-shaped notch anteriorly (Fig. 4).

Biology.—All known specimens were collected in May.

Distribution.—Very few specimens are available for study. The known range presently includes California, British Columbia, and Utah.

Material examined.—Both species were previously known only from the types. In addition to the type material listed above, the following specimen was examined: USA: UTAH: Summit Co., Yellow Pine Campground, 27 May 1980, R. Shaha, 1 ♂ (BYU).

Bibio palliatus McAtee, New Status
(Figs. 5, 8)

Bibio xanthopus palliatus McAtee 1922: 16. Holotype male, allotype female (same pin) (USNM), USA: Idaho, Moscow, 7 May 1894; examined.

Bibio signatus Hardy 1937: 208. Holotype male (BYU), USA: Utah, Spanish Fork, 29 April 1936, D.E. Hardy; examined. (synonymized with *B. palliatus* by Hardy 1945).

Discussion.—*Bibio x. palliatus* was originally described by McAtee (1922) as a subspecies of *B. xanthopus* Wiedemann (1828: 80) for those specimens differing from "typical" *xanthopus* by the coloration of the legs and thoracic pile, and relative size. Hardy (1937) described *B. signatus* as a distinct species, later synonymized it with *B. x. palliatus* (Hardy 1945), and eventually considered both as synonyms of *B. xantho-*

pus (Hardy 1965). Examination of the terminalia of male holotypes of *B. signatus* and *B. x. palliatus,* as well as many specimens of *B. xanthopus,* indicates that *B. palliatus* should be considered a distinct species. Females of the two species are presently indistinguishable.

Although the type of *B. xanthopus* is a female (Hardy 1967), the identity of this species cannot be mistaken for *B. palliatus* due to geographic proximity. *Bibio xanthopus* was described from New York and is widespread throughout the United States (as Hardy 1945), whereas *B. palliatus* is restricted to the northwestern United States and southwestern Canada.

Hardy (1945) provided some characters for the separation of the larvae of *B. xanthopus* and *B. palliatus.*

Diagnosis.—Males of *B. palliatus* are most similar to *B. xanthopus* and *B. similis* James, but can be distinguished by the apical portion of the gonostylus very short in dorsal view (Fig. 5) and the basal portion of the gonostylus broadly rounded in posterior view (Fig. 8), whereas *B. xanthopus* and *B. similis* have the apical portion of the gonostylus more elongate in dorsal view (Fig. 6 and 7) and the basal portion of the gonostylus more slender in posterior view (Figs. 9 and 10). Males of *B. palliatus* can also be distinguished by the following combination of characters: Anterior spur of fore tibia one-half to two-thirds (usually just over one-half) length of posterior spine; posterior veins darker than membrane; hind tibial spur slender; gonostylus with distal portion very short in dorsal view (Fig. 5), and broadly rounded basally in posterior view (Fig. 8 and also Hardy 1961: 187, Fig. 7c; this figure is under the name *B. utahensis* (see discussion of *B. similis*)); hind basitarsus not swollen, elongate, robust; sensilla of hind tibia number approximately 21–88 (N = 24).

Variation.—The leg color is extremely variable, ranging from orange yellow with dark joints, to entirely black, to dark brown to black with base of hind femur yellow, to entirely orange yellow with dark joints and the apical three-quarters of the hind tibia brown black and tarsi brown black, to the hind femur black and the tibia and tarsi brown orange. Although McAtee (1922) described *B. palliatus* as having "somewhat greater average size", wing length ranges from about 5–8 mm, which broadly overlaps the range of wing length of *B. xanthopus.* The r-m crossvein ranges from one-third to equal the length of the base of Rs.

Biology.—The flight period is March–June, with most records in April and May. Adults have been collected from wetlands in Utah and along streams, rivers, lakes, reservoirs, ponds, and springs in other areas of the West, which would suggest that moist or saturated soils are the preferred larval habitat. However, adults have also been collected from sand dunes with vegetation in Washington. Specimens have been taken at elevations of 610–762 m in Washington and approximately 1525 m in Colorado.

Distribution.—Northwestern United States and southwestern Canada: Alberta, British Columbia, California, Colorado, Idaho, Montana, Nevada, Oregon, western South Dakota, Utah, Washington, and Wyoming.

Material examined.—In addition to the type material, the following material was examined: CANADA: ALBERTA: Belly River Campground, Waterton Lakes National Park, 22 May 1993, Baumann & Liu, 1 ♂ (BYU); North Willow Creek, highway 22, 28 May 1993, Baumann & Liu, 3 ♂ (BYU); USA: CALIFORNIA: Nevada Co., Bear River, highway 20, Placer Co. line, 21 April 1987, Baumann, Nelson & Wells, 1 ♂ (in alcohol) (BYU); COLORADO: Larimer Co., Dixon Reservoir, 14 May 1994, B.C. Kondratieff, 2 ♂ (CSUFC); IDAHO: Nez Perce Co., Mission Creek, highway 95, 2 miles west of Culde Sac, 27 April 1985, Baumann & Nelson, 1 ♂ (BYU); MONTANA: Glacier Co., South Fork Cut Bank Creek, highway 89 north of Kiowa, 22 May 1993, Baumann & Liu, 5 ♂ (BYU); Teton Co., North Fork Sun River, highway 287 north of Augusta, 21 May 1993, Baumann & Liu, 1 ♂ (BYU); OREGON: Multnomah Co., Wahkeena Creek at Wahkeena Falls, 29 March 1984, G.R. Fiala, 1 ♂ (in alcohol) (BYU); Umatilla Co., Wildhorse Creek at Athena, 25 April 1985, Baumann & Nelson, 3 ♂ (in alcohol) (BYU); Wallowa Co., Rock Creek, highway 82, 3 miles northwest of Wallowa, 19 May 1977, Baumann & Dunster, 4 ♂ 8 ♀ (in alcohol) (BYU); SOUTH DAKOTA: Custer Co., Iron Creek, Dakota Lake, 5 June 1995, Baumann & Huntsman, 1 ♂ (BYU); Pennington Co.: spring at Whitewood Creek, 7 June 1995, Baumann & Huntsman, 4 ♂ (BYU); Iron Creek, Spearfish Canyon, 7 June 1995, Baumann & Huntsman, 1 ♂ (BYU); UTAH: Washington Co., Santa Clara River, headwaters, North Juniper Campground, 26 May 1976, Baumann, 1 ♂ (in alcohol) (BYU); Utah Co.: Powell Slough, 8 May 1980, S.M. Clark, 4 ♂ (CSUFC); Lehi Environs., 4 May 1968, W. Clark, 1 ♂ (BYU); Provo, 26 May 1955, 1 ♂ (BYU); South Fork of Provo Canyon, Agnes Hardy, 1 ♂ (this specimen is part of the paratype series of *B. utahensis* Hardy) (BYU); Provo, 26 April 1958, S.K. Taylor, 2 ♂ (BYU); Goshen Pond, 8 May 1973, S.B. Shurtleff, 1 ♂ (BYU); Goshen Springs, 1 May 1965, W.M. Tingey, 1 ♂ (BYU); wetland west of Utah Valley State College, 4 May 1996, R.W. Baumann, 14 ♂ 1 ♀ (BYU), 14 ♂ 1 ♀ (CSUFC); Provo, Environs, L.E. Perry, 7 ♂ (BYU); Provo, Environs, 6 May 1969, 1 ♂ (CSUFC); WASHINGTON: Benton Co., Hanford Site, sand dunes with vegetation near Hanford townsite, T12N R28E Section 5, 20 April 1994, R.S. Zach, 5 ♂ 1 ♀ (CSUFC); King Co.: Seattle, 10 April 1933, 1 ♂ (CSUFC); Fall City, 14 April 1970, D.R. Harris, 1 ♂ 1 ♀ (CSUFC); Kittitas Co., Yakima River, highway 90, Cle Elum, 6 May 1982, Baumann & Smith, 1 ♂ 1 ♀ (in alcohol) (BYU); Whitman Co.: Pullman, April, 2 ♂ (USNM); Pullman, 2000–2500 ft., 20 April 1991, P. McLellan, 1 ♂ 1 ♀ (CSUFC); Pullman, May 1921, 2 ♂ (CSUFC); Pullman, 8 May 1931, 1 ♂ (CSUFC); WYOMING: Crook Co., Belle Fourche River at Hulett, 8 June 1995, Baumann & Huntsman, 2 ♂ (BYU); Niobrara Co., Quinn Creek, highway 20 at Lusk, 2 June 1995, Baumann & Huntsman, 4 ♂ 2 ♀ (BYU).

Bibio similis James
(Figs. 7, 10)

Bibio similis James 1936: 5. Holotype male (AMNH), USA: Colorado, Boulder, 5 May 1934, M.T. James; examined.

Bibio utahensis Hardy 1937: 208. Holotype male (BYU), USA: Utah, Utah Co., Provo environs., Harry Thomas; examined. **New Synonym.**

Discussion.—The holotype of *B. utahensis* is conspecific with *B. similis*. However, the paratype series of *B. utahensis* is composed of two species, *B. similis* and *B. palliatus*, only separable by examination of male terminalia. Hardy (1961) illustrated (p. 187, Figs. 7a–7c) the male terminalia and hind and fore tibia of *B. palliatus* under the name *B. utahensis*.

Diagnosis.—Males of *B. similis* are most similar to *B. xanthopus* and *B. palliatus*. Males of *B. similis* can be distinguished from *B. xanthopus* by the longer anterior spur of the fore tibia, legs usually dark brown to black, and the more slender base of the gonostylus in posterior view (compare Figs. 9 and 10). *Bibio similis* can be distinguished from *B. palliatus* only by examination of male terminalia; the gonostylus of *B. palliatus* is robust and broadly rounded basally in posterior view (Fig. 8) with a very short apical portion in dorsal view (Fig. 5), whereas the gonostylus of *B. similis* is slender basally in posterior view (Fig. 10) with the apical portion in dorsal view, not shortened, but developed into a longer, simple, digitate process with a blunt apices (Fig. 7). Males of *B. similis* can also be distinguished by the following combination of characters: Legs predominantly black (see variation below); anterior spur of fore tibia one-half to three-fourths length of posterior spine; posterior veins darker than membrane; hind basitarsus not swollen; hind tibial spur slender; sensilla of hind tibia number approximately 21–51 (N = 18); gonostylus basally slender and distally elongate (Figs. 7 and 10).

Variation.—In males thoracic pile color ranges from yellow to black to intermixed, and the legs range in color from black to dark brown to the femora blackish and the tibia and tarsi brown orange.

Although *B. similis* was originally described with the anterior spur of the fore tibia not being over one-fourth the length of the posterior spine, a study of the holotype, paratypes, and additional material, reveals that the anterior spur ranges from one-half to three-fourths the length of the posterior spine.

Biology.—The flight period is April and May. It has been taken on flowers of *Salix* (Salicaceae) in Colorado. Adults seem to be most commonly collected along creeks, ponds, and rivers, and the larvae may prefer moist or saturated soils.

Distribution.—Northwestern United States: Colorado, Oregon, Western South Dakota, Utah, and Washington.

Material examined.—In addition to the types, the following material was examined: USA: COLORADO: Boulder Co., Sawhill Ponds, 14 May 1994, B. Kondratieff & R. Durfee, 12 ♂ 6 ♀ (one pair in copula) (CSUFC); Delta Co., 5 miles northeast of Delta off highway 65, 3 May 1987, U.N. Lanham & M. Weissmann, 1 ♂ (CSUFC), 6 ♂ (UColB); Douglas Co., 5 miles southeast of Franktown, *Salix* flowers, 26 April 1963, U.N. Lanham, 1 ♂ (UColB); Garfield Co., Grizzly Creek, 9 May 1995, W. Cranshaw, 4 ♂ 1 ♀ (CSUFC); Larimer Co., N. Colorado Nature Center, 25 May 1987, B.C. Kondratieff, 1 ♂ (CSUFC); OREGON: Umatilla Co.: Umatilla River at Mission, 5 miles east of Pendleton, 25 April 1985, Baumann & Nelson, 2 ♂ (in alcohol) (BYU); Walla Walla River in Milton-Freewater, 25 April 1985, Baumann & Nelson, 1 ♂ (in alcohol) (BYU); Union Co., Phillips Creek, highway 82, Elgin, 19 April 1977, Baumann, 1 ♂ (in alcohol) (BYU); Wallowa Co., Rock Creek, highway 82, 3 miles northwest of Wallowa, 19 May 1977, Baumann & Dunster, 1 ♂ (in alcohol) (BYU); SOUTH DAKOTA: Lawrence Co., Whitwood Creek between junction Yellow and White Tail Creeks (WW-09), 19 May 1981, Baumann & Furnish, 1 ♂ (in alcohol) (BYU); UTAH: Cache Co., Blacksmith Fork Canyon, 21 May 1983, C.R. Nelson, 1 ♂ (BYU); Utah Co.: East side Utah Lake: 10 ♂ (BYU); V.M. Tanner, 3 ♂ (CSUFC); 20 April 1957, H.P. Shurtleff, 1 ♂ 1 ♀ (CSUFC); Wasatch Co., spring tribs. of Provo River near Hoovers, 14 May 1987, Nelson & Wells, 1 ♂ (BYU); WASHINGTON: Kittitas Co., Teanaway River, highway 10, 4 miles south of Cle Elum, 6 May 1982, Baumann & Smith, 5 ♂ (in alcohol) (BYU).

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A NEW SPECIES OF MEALYBUG IN THE GENUS *PSEUDOCOCCUS* (HOMOPTERA: PSEUDOCOCCIDAE) OF QUARANTINE IMPORTANCE

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Abstract.—A new species of mealybug, ***Pseudococcus odermatti,*** is described that has been taken in quarantine on *Aglaonema, Citrus,* and other plants and is of concern as a pest. Since it is frequently taken in quarantine at US ports of entry, it is important that the species be described. The adult female and third-instar female are described and illustrated and are incorporated in a key.

Key Words: Mealybugs, Coccoidea, Pseudococcidae, quarantine, citrus, *Aglaonema*

The genus *Pseudococcus* encompasses more than 150 species of mealybugs (Ben-Dov 1994) including several major pests such as the citrophilus mealybug *P. calceolariae* (Maskell), the long-tailed mealybug *P. longispinus* (Targioni Tozzetti), the grape mealybug *P. maritimus* (Ehrhorn), and the obscure mealybug *P. viburni* (Signoret) (hitherto known as *P. affinis* (Maskell) see Ben-Dov and Matile-Ferrero 1995). In recent years an undescribed species of *Pseudococcus* has been intercepted at ports-of-entry in the United States and Japan and has impacted the movement of citrus fruit between Florida and Japan and between the Bahamas and the United States. It has potential quarantine implications on the World movement of ornamentals such as *Aglaonema* (Araceae). The genus *Aglaonema* contains many species grown as ornamentals in subtropical areas and in greenhouses.

The purpose of this research is 1) to describe the morphological characters of this undescribed species so that they can be used to differentiate it from similar species, 2) provide data on hosts and distribution, and 3) incorporate the species in keys to adult females of *Pseudococcus* so that it can be accurately identified.

Methods

Terminology in the descriptions follows that of Williams and Watson (1988) and Gimpel and Miller (1996). The cerarii are numbered forward from the anal lobe pair (number 1) to the frontal pair (number 17). The cerarian formula is given as the cerarian number with the number of conical setae in parentheses. For example, the cerarian formula 1–11(2) means that cerarii numbers 1 through 11 each have 2 conical setae. Measurements and numbers are from 10 specimens when available, and are given as an average followed by the range in parentheses. Depositories of specimens are: The Natural History Museum, London (BMNH); California Department of Food and Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); Muséum National d'Histoire Naturelle, Paris (MNHN); University of California, Davis (UCD); National Museum of Natural History, Beltsville, MD (USNM).

Results

Pseudococcus odermatti Miller and Williams, new species

Figs. 1, 2

Type data.—The adult female holotype is the right specimen of two on a slide with the left label "Pseudococcus/12/ Costa Rica/ ex Aglaonema sp./ IV-29-76 leaf/ Miami 13578/ E. B. Lee/ Balsam" right label "*Pseudococcus odermatti* Miller/and Williams/HOLOTYPE" with a map giving the position of the holotype. This slide is deposited in the USNM. In addition there are paratypes that are deposited in BMNH, CDA, FSCA, MNHN, UCD, USNM.

Etymology.—The species epithet is given in recognition of the many contributions of Douglas M. Odermatt, Entomologist, Animal and Plant Health Inspection Service (APHIS), who has not only provided many specimens of this species, but also has added significantly to our knowledge of scale insects through the thousands of identifications that he has provided for APHIS identifiers each year.

Adult female. Slide-mounted characters.—Holotype oval, length 2.6 mm, width 1.6 mm. Paratypes 2.6(1.9–3.1) mm long, 1.5(1.0–1.9) mm wide.

Dorsum with 17 pairs of cerarii, cerarian formula as follows: Left side 1–9(2), 10(3), 11(2), 12(3), 13–14(2), 15(3), 16(4), 17(3); paratypes rarely with 1 conical seta in cerarii 9 and 10, 3(2–4) conical setae in cerarius 12, with 3(2–3) in cerarius 14, with 4(3–5) in cerarius 16, and 3(3–4) in cerarius 17. Cerarius 12 with 4 auxiliary setae (paratypes with 2(1–4) setae), 18 trilocular pores (paratypes with 18(12–22) pores), and 2 discoidal pores (paratypes with 1(0–3) pores). Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores of 2 sizes, those associated with oral-rim or oral-collar tubular ducts small, about ¼ diameter of trilocular pore, those scattered over surface larger, about ½ size of trilocular pore. Oral-rim tubular ducts each with 1(0–2) associated discoidal pores, without closely associated setae, oral rims present submarginally posterior of frontal cerarius, absent between cerarii 15 and 16, present between cerarii 13 and 14, also present near cerarii 4–8, 11, and 12 (paratypes also usually with oral rims near cerarii 2 and 9, rarely with oral rim near cerarius 10), also present submedially and medially, with 17 oral rims on abdomen (paratypes with 19(16–22) oral rims). Oral-collar tubular ducts present marginally and submarginally around perimeter of body, also present medially and submedially on anterior abdominal segments, thorax, and head, often with 1 or 2 associated discoidal pores, wall of tube heavily sclerotized, giving bright orange appearance with phase contrast microscopy. Longest submedial seta on abdominal segment VII 57μ long (paratypes 66(49–101) μ); 5 submedial setae on abdominal segment VIII (paratypes 4(2–8) setae), longest seta 52 μ long (paratypes 49(37–72) μ).

Anal ring setae 163 μ long (paratypes 169(151–195) μ); 1.7 times as long as greatest diameter of ring (paratypes 1.6(1.4–1.9) times).

Venter with multilocular pores in posterior and anterior bands on abdominal segments V–VIII, in posterior band on abdominal segment IV (paratypes sometimes with 1 or 2 pores near anterior margin of abdominal segment IV, rarely with only 1 or 2 pores near anterior margin of abdominal segment III), with 6 pores on thorax (paratypes with 7(1–16) pores). Trilocular pores scattered over surface. Discoidal pores of same 2 sizes as on dorsum, smaller size associated with oral rims, larger size scattered over surface, without a discoidal near eye. Oral-rim tubular ducts usually with 1 associated discoidal, without associated setae, with 5 ducts on submargin from segment II to cerarius 13 (paratypes with 5(4–12) ducts), without duct near frontal cerarius. Oral-collar tubular ducts of 2 sizes, larger size present near posterior band of multilocular pores and on marginal and submarginal areas of abdomen, thorax, and head;

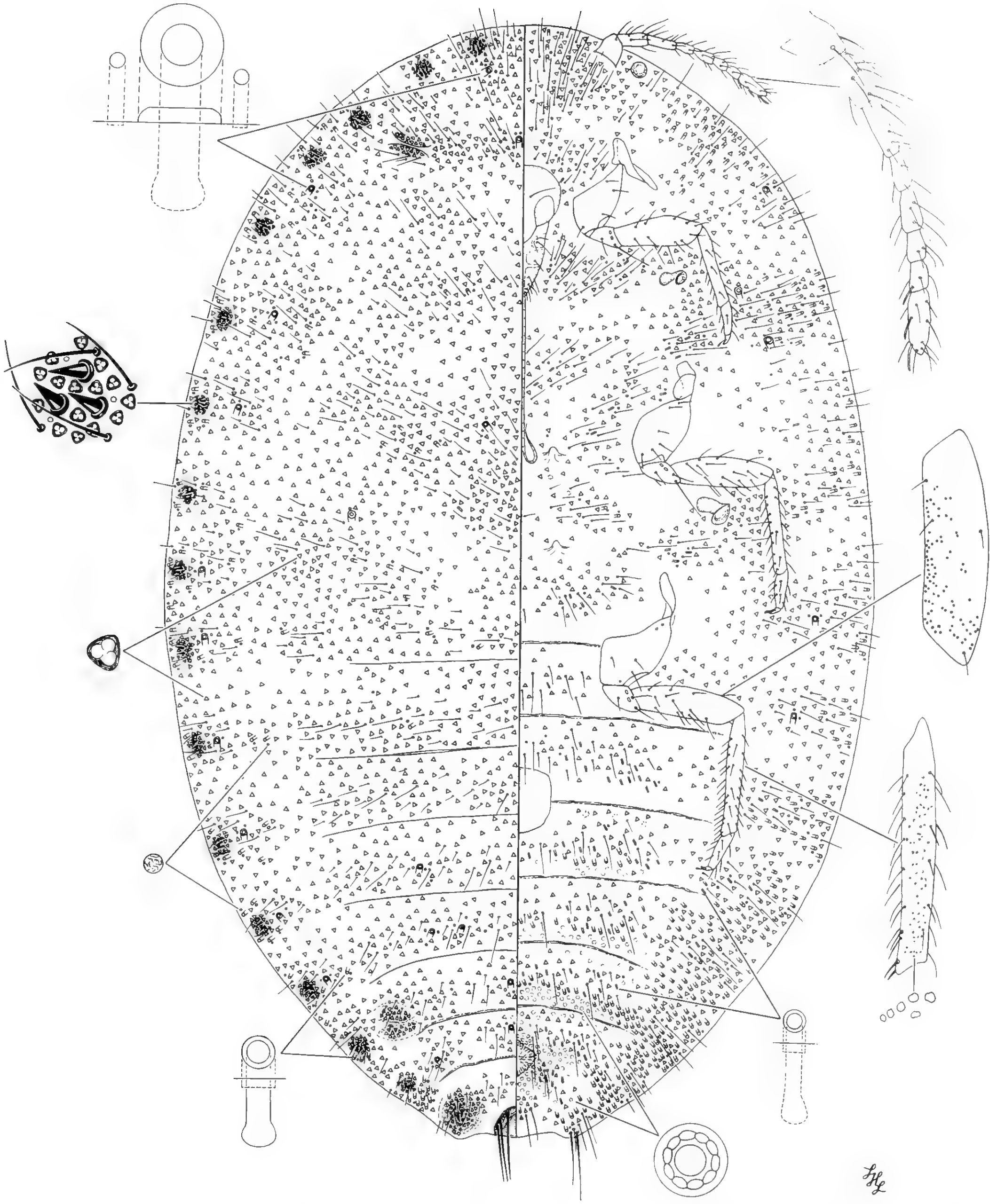

Fig. 1. Adult female *Pseudococcus odermatti* Miller and Williams. Costa Rica: April 29, 1976, on *Aglaonema* sp. leaf, E. B. Lee (taken in quarantine at Miami, FL).

smaller size near setal bases in medial and submedial areas of abdomen and thorax, 7 oral collars mesad of cerarius 12 (paratypes 10(7–13) ducts), 9 associated with cerarii 10 and 11 (paratypes with 12(8–15) ducts), 22 posterior of eye (paratypes 21(16–33) ducts), 8 on each side of head (paratypes 4(2–6) ducts). Setae as follows: 4 cisanal, longest 79μ long (paratypes 71(52–89)μ); longest anal-lobe seta 143μ long (paratypes

160(128–190)μ); longest seta on trochanter 148μ long (paratypes 136(128–163)μ).

Circulus 168 μ wide (paratypes 153(130–170)μ), divided by intersegmental fold. Labium 165μ long (paratypes 160(148–203)μ). Antennae 8-segmented, 490μ long (paratypes 431(384–620)μ). Legs with 95 translucent pores on hind femur (paratypes 118(43–222) pores); 55 pores on hind tibia (paratypes 95(41–144) pores). Femur 279μ long (paratypes 276(229–329)μ); tibia 279μ long (paratypes 277(242–353)μ); tarsus 114μ long (paratypes 108(99–124)μ). Tibia/tarsus 2.4 (paratypes 2.6(2.4–3.3)). Hind tibia with 30 setae (paratypes 29(26–35) setae).

Notes.—The adult females are variable in the number of dorsal oral-collar tubular ducts, the size of the legs, antennae, and labium, the number of translucent pores on the hind femur and tibia, and the length of the dorsal setae. In general, New World populations often have shorter dorsal setae, Chinese specimens have more translucent pores, and Japanese populations have longer appendages and a larger tibia/tarsus statistic. However, this variation overlaps sufficiently among specimens collected at various localities to suggest that there is only one highly variable species.

Third-instar female. Slide-mounted characters.—Body oval, length 1.3(1.2–1.4) mm, width 0.8(0.7–0.8) mm.

Dorsum with 17 pairs of cerarii, cerarian formula as follows: 1–11(2), 12(3 rarely 2), 13–14(2 rarely 3), 15(3 rarely 1 or 2), 16(3 or 4), 17(3 rarely 4). Cerarius 12 with 1(0–1) auxiliary setae), 5(3–6) trilocular pores), without associated discoidal pores. Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores of 2 sizes, those associated with oral-rim or oral-collar tubular ducts small, about ¼ diameter of trilocular pore, those present in medial areas of abdominal segments VII and VIII larger, about ½ size of trilocular pore. Oral-rim tubular ducts with 1(0–1) associated discoidal pores, without closely associated setae, oral rims present submarginally posterior of frontal cerarius, associated with cerarii 12, 8, and 5, rarely 1 duct missing on 1 side of body, also present submedially on 1 or both sides of metathorax with 4(3–4) oral rims on abdomen, 5(5–6) on thorax and head. Oral-collar tubular ducts present marginally and submarginally around perimeter of body, also present submedially on anterior abdominal segments, thorax, and head, often with 1 or 2 associated discoidal pores, wall of tube heavily sclerotized, giving bright orange appearance with phase contrast microscopy. Longest submedial seta on abdominal segment VII 30(28–32)μ long; 2 submedial setae on abdominal segment VIII, longest seta 23(20–27)μ long.

Anal ring setae 109(104–116)μ long; 1.6(1.5–1.8) times as long as greatest diameter of ring.

Venter without multilocular pores; trilocular pores scattered over surface. Discoidal pores same as on dorsum, smaller size associated with oral rims, larger size in submedial line on each side of abdomen. Oral-rim tubular ducts usually with 1 associated discoidal, without associated setae, with 2(1–4) ducts on submargin from abdominal segment II to cerarius 13, without duct near frontal cerarius. Oral-collar tubular ducts of 2 sizes, larger size on marginal and submarginal areas of abdomen, thorax, and head; smaller size near setal bases in medial and submedial areas of thorax, 1(0–1) oral collars mesad of cerarius, 1(0–2) associated with cerarii 10 and 11, 2 posterior of eye, 1(0–1) on each side of head. Setae as follows: 4 cisanal, longest 38(31–42)μ long; longest seta on trochanter 85(72–91)μ long.

Circulus 90(74–99)μ wide, divided by intersegmental fold. Labium 112(104–119)μ long. Antennae 7-segmented, 270(264–273)μ long. Legs without translucent pores. Femur 144(136–149)μ long; tibia 118(109–124)μ long; tarsus 96(96–99)μ long. Tibia/tarsus 1.2(1.1–1.3). Hind tibia with 13(12–15) setae.

Notes.—The description of the third in-

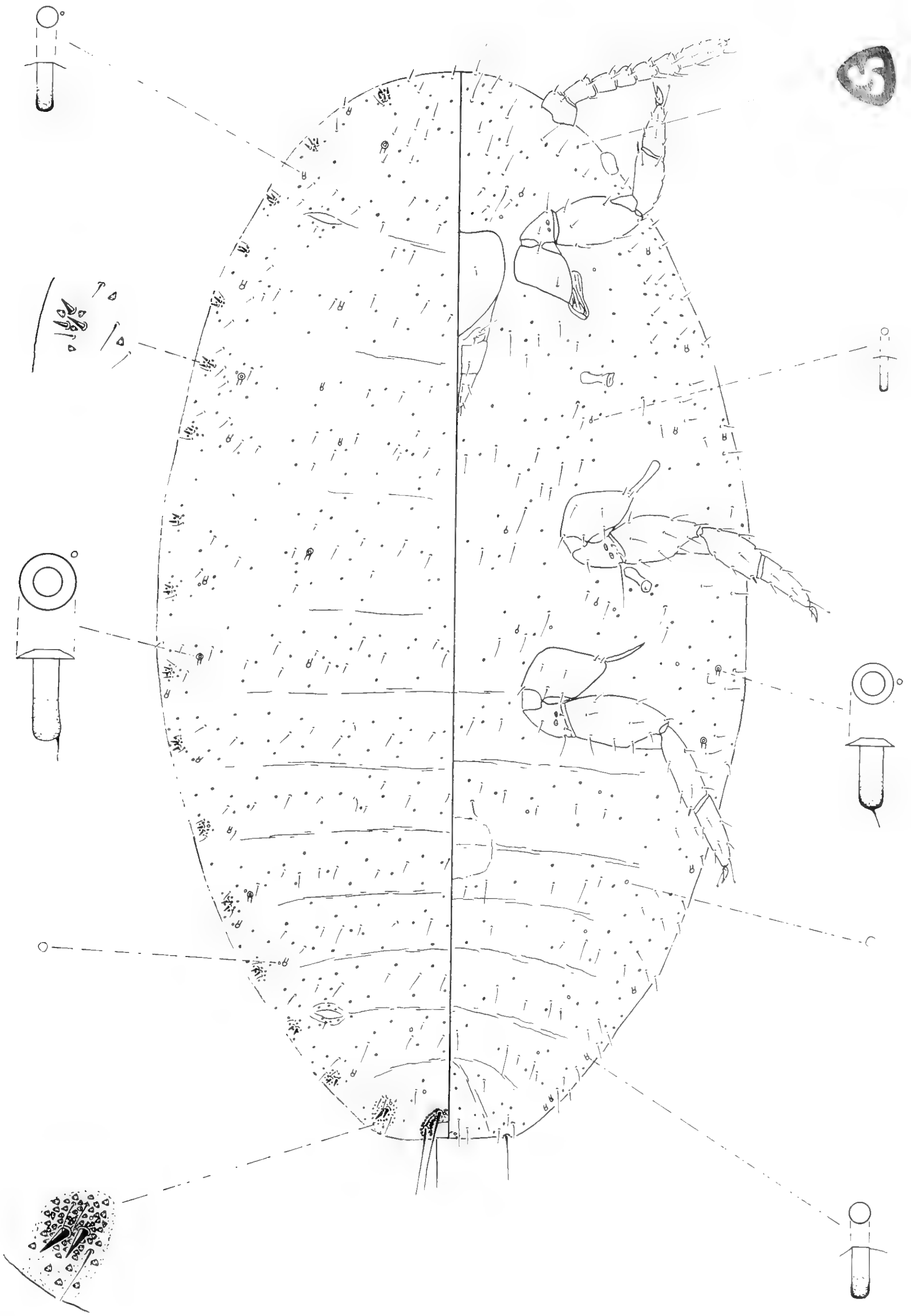

Fig. 2. Third-instar female *Pseudococcus odermatti* Miller and Williams. Belize: April 29, 1976, on *Aglaonema* sp. leaf, E. B. Lee (taken in quarantine at Miami, FL).

star is based on 28 specimens from Belize on *Aglaonema* sp.

Discussion.—*Pseudococcus odermatti* is most similar to *Pseudococcus comstocki* (Kuwana) (see Williams and Granara de Willink 1992) and *P. gilbertensis* Beardsley (see Beardsley 1966). It is easily distinguished from them by the absence of translucent pores on the hind coxae. It also can be distinguished from *P. comstocki* by having no multilocular pores on the ventral surface of abdominal segment II and from *P. gilbertensis* by having more than 5 ventral oral-collar tubular ducts associated with cerarius 12. *Pseudococcus comstocki* has many multiloculars on abdominal segment II and *P. gilbertensis* has fewer than 5 ventral oral-collar tubular ducts associated with cerarius 12.

The area of origin of this species appears to be Old World since its closest relatives seem to be the old world species *P. comstocki* and *P. gilbertensis* and since the most common hosts *Aglaonema* and *Citrus* are from the Old World.

Keys.—The key to adult females of *Pseudococcus* presented by Williams and Granara de Willink (1992) should be modified as follows to accomodate the new species:

Change couplet 7 as follows:

7. Oral-rim tubular ducts absent from head near frontal cerarius; dorsal setae short, less than 30μ long . . . . . . ***calceolariae*** (Maskell)
– Oral-rim tubular ducts on 1 or both sides of head near frontal cerarius; dorsal setae long, at least 40μ long 7A
7A. Oral-rim tubular ducts few, present usually next to frontal cerarii, and between cerarii 15 and 16, and with 1 pair near abdominal cerarii only; absent from midline of abdomen and submarginally . . . . ***agavis*** MacGregor
– Oral-rim tubular ducts relatively abundant, present usually next to frontal, and near cerarii 4–8, 11 and 12, and between 13 and 14; without oral rim between 15 and 16; present near midline of abdomen and submarginally . . . . ***odermatti*** Miller and Williams n.sp.

Specimens Examined.—Paratypes. BAHAMAS: Marsh Harbor, Abaco, X-23-92, on *Citrus paradisi,* R. L. Morris (1 ad ♀ on 1 sl) BMNH; New Providence, XI-8-78, on *Annona squamosa,* C. W. Smith (11 ad ♀, 2 third instar ♀ on 3 sl); no specific locality, II-13-85, on *Aglaonema* sp., H. D. Hannagan (taken in quarantine at Miami, FL)(1 ad ♀ on 1 sl) USNM; no specific locality, I-19-86, on *Annona squamosa,* C. Cohen (1 ad ♀on 1 sl); no specific locality, II-7-94, IX-25-95, on *Citrus latifolia,* R. Morris (taken in quarantine at Ft. Pierce, FL)(2 ad ♀, 1 third instar ♀ on 3 sl) USNM. BELIZE: VIII-13-75, on *Aglaonema* sp., H. L. Rubin (taken in quarantine at Miami, FL)(16 ad ♀, 26 third instar ♀, 2 second instar ♂ on 6 sl) BMNH, CDA, USNM. CHINA: Canton, V-18-37, V-17-39, on *Aglaonema* sp., (taken in quarantine at Washington, DC)(3 ad ♀ on 2 sl) USNM; IV-23-40, IV-26-40, on *Aglaonema* sp., (taken in quarantine at Seattle, WA)(2 ad ♀ on 2 sl) MNHN, USNM. COSTA RICA: IV-29-76, on *Aglaonema* sp. leaf, E. B. Lee (taken in quarantine at Miami, FL)(4 ad ♀ on 4 sl) BMNH, UCD, USNM. HONG KONG: Sheung Shui, IV-13-93, on *Pittosporum tobira,* C. S. K. Lau (1 ad ♀ on 1 sl) BMNH; IV-3-36, V-21-40, on *Aglaonema* sp., Adams and Limber (5 ad ♀ on 2 sl) USNM.

UNITED STATES: FLORIDA: Homestead, III-22-73, on *Pyracantha* sp., W. H. Pierce (1 ad ♀ on 1 sl) FSCA; I-7-93, III-1-93, V-6-93, on grapefruit, T. Sugimoto (taken in quarantine at Yokohama, Japan)(3 ad ♀ on 3 sl) BMNH, USNM. HAWAII: VIII-16-94, on *Diospyros blancoi,* Hara and Maemoto (2 ad ♀ on 2 sl) USNM.

Other material, not paratypes (all in USNM unless otherwise stated). CHINA: IV-26-40, on *Aglaonema* sp., (taken in quarantine at Washington, DC)(2 ad ♀ on 1 sl); V-23-41, IX-23-41, on *Aglaonema* sp., (taken in quarantine at Blaine, WA and Hoboken, NJ)(3 ad ♀ on 2 sl). BAHAMAS: Marsh Harbor, Abaco, X-23-92, on *Citrus paradisi,* R. L. Morris (3 ad ♀ on 3 sl); III-8-94, on *Citrus latifolia,* R. Morris (taken in quarantine at Ft. Pierce, FL)(1 ad ♀on 1 sl) BMNH. JAPAN: VI-20-33, on *Fatsia japonica,* W. H. Wheeler (taken in quarantine at Seattle,WA)(1 ad ♀ on 1 sl); IX-13-35, on *Fatsia japonica,* K. E. Miller (taken in quarantine at New Orleans, LA)(2 ad ♀ on 1 sl).

SUMMARY

Pseudococcus odermatti occurs on a number of agricultural and ornamental hosts and could potentially pose a threat as an important pest. It is reported on *Aglaonema* (Araceae), *Annona* (Annonaceae), *Citrus* (Rutaceae), *Diospyros* (Ebenaceae), *Fatsia* (Araliaceae), *Pittosporum* (Pittosporaceae), *Pyracantha* (Rosaceae), and is known from Florida and Hawaii in the United States and from the Bahamas, Belize, China, Costa Rica, Hong Kong, and Japan.

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SIX NEW SPECIES OF GALL MIDGES (DIPTERA: CECIDOMYIIDAE) FROM *MELALEUCA* (MYRTACEAE) IN AUSTRALIA

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Abstract.—A new genus, ***Lophodiplosis*** **Gagné**, is described for five new species of gall midges from Australia associated with *Melaleuca* spp. At least two of these are candidates for biological control of the introduced pest, *Melaleuca quinquenervia,* or paperbark, in Florida. In addition, a new species of *Lasioptera* is described. The new species are: ***Lophodiplosis indentata*** and ***Lophodiplosis denticulata*** that form blister galls on leaves of *Melaleuca* spp.; ***Lophodiplosis bidentata,*** responsible for rosette bud galls on *Melaleuca* spp.; ***Lophodiplosis cornuata,*** forming trumpet-shaped leaf galls on *Melaleuca viridiflora*; ***Lophodiplosis trifida,*** an inquiline in galls of *L. indentata, L. denticulata,* and *L. bidentata*; and ***Lasioptera uncinata,*** an inquiline in galls of *L. indentata* and *L. cornuata.* Keys are given to adults of Australian genera of the supertribe Cecidomyiidi and to adults and pupae of the six species found on *Melaleuca* spp. during this study.

Key words: gall midges, Cecidomyiidae, *Melaleuca,* Australia

Melaleuca quinquenervia is one of more than 200 species of a large genus of Myrtaceae that is mostly endemic to Australia (Barlow 1988, Holliday 1989). While most *Melaleuca* species are small shrubs, *M. quinquenervia* grows into a robust tree up to 25 m high in Australia (Bodkin 1991) and up to 29 m high in Florida (Rockwood and Geary 1991). It is one of many Australian trees that are popular in plantings in tropical and subtropical regions of the world. Unfortunately, *M. quinquenervia* has become a pest in some locations in the United States. It is considered the most troublesome terrestrial weed in Florida (Florida Conservation Foundation (1993) where it was introduced in 1906 (Schmitz et al. 1991). It is a lesser pest on some Hawaiian Islands (Balciunas, unpublished). In southern Florida this plant now occupies at least 500,000 acres (Bodle et al. 1994), causing extensive environmental and economic damage (Balciunas and Center 1991). Even small trees produce a great number of seeds that in Florida, unlike in Australia, result in a thick carpet of seedlings that in a few years form dense, monospecies forests (Balciunas, personal observation). In Australia, native insects suppress the growth of saplings (Balciunas and Burrows 1993). In Florida, conventional control measures, such as cutting, burning, and herbicides, have proven to be ineffective, costly, or environmentally inappropriate in managing this pest. Since 1986, a consortium of Florida and U.S. agencies has supported a U.S. Department of Agriculture project in Australia to locate, test, and export potential biological control agents to help control this weed. The faunal surveys of *M. quinquenervia,* the largest plant ever targeted for a classical biological control effort (Balciunas et al. 1994), have found more than 450 herbivorous insects associated with this tree in Australia (Balciunas et al. 1995). Included among these insects are gall midges that form or are associates of various leaf and bud galls. This paper treats six species of gall midges found associated with three kinds of galls (Figs. 1–6) on *M. quinquenervia* and some of its close allies in the *Melaleuca leucadendra* group (Blake 1968).

All six species of Cecidomyiidae are new to science and described here. Four species are gall makers and the remaining two are presumed to be inquilines or successors. The gall midges causing leaf blister and bud rosette galls show potential as biological control agents and will be investigated further. The leaf blister galls were the most commonly found in our survey and abundant from August to November with the emergence of new leaves. Heavily infested leaves may be rolled or otherwise distorted, but even small numbers of galls are a tax on the host's energy. The rosette bud galls appear to have a more deleterious effect on *Melaleuca quinquenervia* by killing branch terminals.

METHODS AND MATERIALS

Surveying, collecting, and rearing for this study in Australia were done by the staff of the Australian Biological Control Laboratory under the direction of JKB and DWB. Galls were collected on members of the *Melaleuca leucadendra* complex mainly in coastal areas of Queensland between Townsville (19°28'S) and Cairns (16°54'S). Some collections were also made in the vicinity of Brisbane (27°30'S) in southern Queensland and of Cooktown (15°28'S) in northern Queensland. Plant species sampled were: *Melaleuca arcana* S.T. Blake, *M. dealbata* S.T. Blake, *M. "fluviatilis"* (Barlow 1988), *M. leucadendra* (L.) L., *M. quinquenervia* (Cav.) S.T. Blake, *M. saligna* Schauer, and *M. viridiflora* Sol. ex Gaertner. Galls from the field were either preserved in alcohol or kept in small plastic containers that were checked daily for emergence. Larvae and pupae were excised from sample galls, adults were reared and their pupal exuviae saved, and all specimens were preserved in 70% ethanol. Some larvae and adults were mounted for microscopic study in Canada balsam, using the method outlined in Gagné (1989a, 1994), some were prepared for SEM viewing. In the following descriptions, anatomical terminology of the adult stage follows McAlpine (1981) and that of the larval stage follows Gagné (1989a). Specimens used in this study are deposited in the Australian National Insect Collection, Canberra (ANIC) or the U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). Other abbreviations used in the text are for collectors in the lists of specimens studied: ADM = A.D. Moore; DWB = D.W. Burrows; JKB = J.K. Balciunas; RJG = R.J. Gagné.

Lophodiplosis Gagné, new genus

Adult.—Head: Eyes large, connate, eye bridge about 12 facets long; facets hexagonal, closely adjacent throughout. Vertex with short to long dorsal protuberance bearing 2–6 setae. Frons with 6–12 setae. Labella elongate-hemispherical in frontal view, the apices incurved and acute, each with 5–12 setae. Palpus 4 segmented. Antenna with 12 flagellomeres, first and second flagellomeres connate, apex of twelfth flagellomere with narrow, elongate extension. Male flagellomeres binodal, sometimes weakly so, with 1 circumfilum on basal node, 2 on distal node, circumfila separate or running into one another, the loops short to long. Female flagellomeres becoming successively slightly shorter from base to apex of antenna, nodes parallel sided or constricted near middle, necks prominent and without setulae; circumfila made up of two wavy horizontal bands connected by 2 vertical bands, closely embracing node for all or most of extent.

Thorax: Scutum with 2 lateral and 2 dorsocentral rows of setae interspersed with sparse scales. Mesanepisternum covered with scales on dorsal half to two thirds. Mesepimeron with vertical row of setae. Wing: R_5 curved apically to join C posterior to wing apex; C broken beyond juncture with R_5; Rs apparent as spur of R_5, variable in position; Cu forked; M_{3+4} present as fold. Tarsal claws curved beyond midlength, one- or two-toothed or simple; empodia almost reaching bend in claws; pulvilli about one fourth length of empodia.

Male abdomen: First through sixth tergites entire, rectangular, with posterior row of setae, usually with lateral setae, anterior pair of trichoid sensilla, and otherwise mostly covered with setiform scales. Seventh and eighth tergites more weakly sclerotized; seventh tergite usually with 1–several posterolateral setae, a few scales, with anterior pair of trichoid sensilla; eighth tergite bare except for anterior pair of trichoid sensilla. Cerci variable, triangular or ovoid. Hypoproct bilobed, variable in shape and vestiture. Aedeagus short to moderately long. Gonocoxite with small, obtuse mesobasal lobe. Gonostylus tapered gradually from wide base to narrower, toothed apex, with scattered setae, setulose basally, remainder of surface marked with minute longitudinal ridges.

Female abdomen: First through seventh tergites entire, rectangular, with posterior row or rows of setae, usually with lateral group of setae, anterior pair of trichoid sensilla, and otherwise covered with setiform scales; eighth tergite shorter, narrower, and more weakly sclerotized than preceding, with either weak, scattered setae or strong setae mixed with scales posteriorly and anterior pair of trichoid sensilla; ovipositor short-protrusible, less than 1½ length of seventh tergite, with ventral setae on intersegmental membrane, evenly distributed setae on ninth segment, with or without setae on tenth tergum; cerci short to long, more or less bilaterally flattened, with 2–4 ventroapical, thick, setiform sensoria on each, and otherwise covered with setulae; hypoproct variably shaped.

Pupa.—Vertex with conspicuous projection. Two pairs of vertexal papillae present, one of each pair with elongate seta and enlarged base. Antennal bases evenly rounded or angular. Face with or without horns, with or without pair of setae mesally. Prothoracic spiracle several times as long as wide. Abdominal segments uniformly spiculose, without spines.

Larva.—Third instar: Body flattened-cylindrical, rounded at both ends. Integument mostly rugose. Antenna less than twice as long as wide. Spatula with two acutely triangular anterior projections, intervening concavity smooth to minutely dentate. Papillar pattern generally as for Cecidomyiidi (Gagné 1989a): lateral papillae on each side of spatula reduced in some species to the two setose pairs; dorsal and pleural papillae with setae little longer than wide; terminal segment with 2 or 4 pairs of papillae.

Second instar: Spatula present. Otherwise as for third instar.

Type species.—*Lophodiplosis indentata* Gagné.

Etymology.—*Lophodiplosis* is of feminine gender and combines the Greek "lophos," meaning "crest" with "diplosis." The prefix refers to the protruding vertex of the pupa. The suffix has been commonly used for genera of the supertribe Cecidomyiidi and means "double," with reference to the binodal male flagellomeres.

Relationships.—*Lophodiplosis* belongs to the supertribe Cecidomyiidi. Uniquely derived characters (sometimes secondarily lost) of the supertribe are the dorsal protuberance of the adult head and the binodal, tricircumfilar male antennal flagellomeres. This genus differs from all other known genera of Cecidomyiidi except *Acacidiplosis* in the development of the pupal vertex into a protuberance or crest instead of or in addition to the antennal horns. This development appears to be another strategy to allow pupae to cut their way out of the galls. Although the five species placed here are otherwise diverse, we regard the pupal head character as a shared, derived character until we have better knowledge of the Australian cecidomyiid fauna. The presence of a similar modification in *Acacidiplosis,* an African genus restricted to *Acacia* spp., presumably arose separately in that genus because not all *Acacidiplosis* species have it (Gagné and Marohasy 1994) and the two genera share no other obvious derived characters. *Acacidiplosis* differs from *Lophodiplosis* in having no vertexal protuberance in the adult, less than four palpal segments, and small, asetulose, dorsoventrally compressed and mesally joined female cerci.

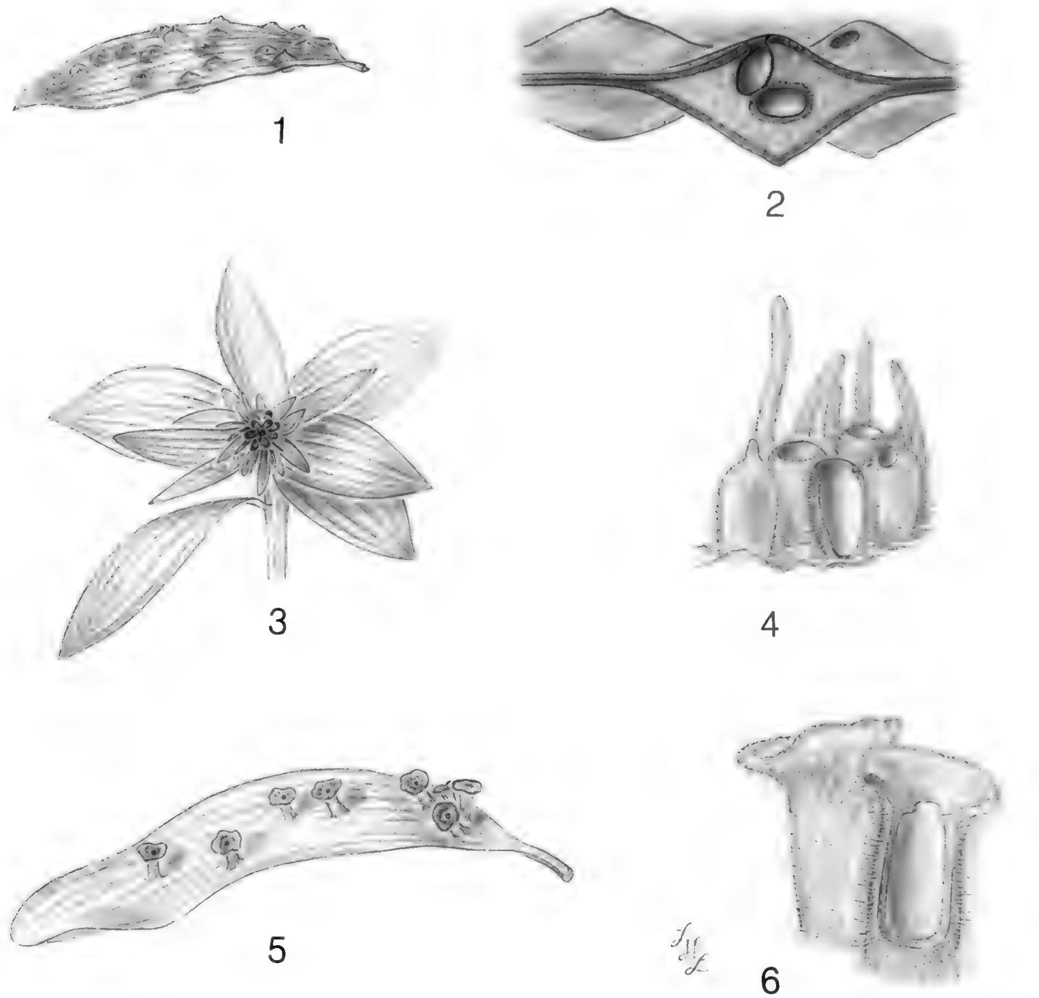
KEY TO ADULTS OF AUSTRALIAN GENERA OF THE SUPERTRIBE CECIDOMYIIDI

Lophodiplosis is the first genus of Cecidomyiidi outside of the tribe Asphondyliini to be based exclusively on Australian species. Except for the Skuse species, which remain essentially unknown (Gagné 1989b), all the non-asphondyliine Cecidomyiidi identified from Australia to date are satisfactorily placed in cosmopolitan genera (Gagné 1989b). The nine genera keyed below are doubtless only a small sample of what will be found in Australia, but the key serves to place *Lophodiplosis* for future identification. Following each generic name is the most up-to-date and comprehensive reference. For a list of Australian species in each of the genera, see Gagné (1989b).

1\. Male gonostylus situated on dorsum of gonocoxite; female seventh sternite at least 1½ times length of sixth sternite 2
– Male gonostylus situated on apex of gonocoxite; female seventh sternite not appreciably longer than sixth 4
2\. Empodia much shorter than tarsal claws; male flagellomeres with necks; female without dorsal pair of lobes at base of intersegmental membrane of ovipositor . . . . *Skusemyia* (see Kolesik 1995a)
– Empodia as long as tarsal claws; male flagellomeres without necks; female with dorsal pair of lobes at base of intersegmental membrane of ovipositor 3
3\. Surface of flagellomeres covered with closely anastomozing circumfila; ovipositor short, pliable . . . . . . *Eocincticornia* (see Kolesik 1995b)
– Surface of flagellomeres with only weakly anastomozing circumfila in male but not in female; ovipositor long, needle-like, sclerotized . . . . *Asphondylia* (see Gagné 1994)
4\. Tarsal claws curved near basal third 5
– Tarsal claws curved beyond midlength 6
5\. Head without vertexal protuberance . . . . *Diadiplosis* (see Gagné 1994)
– Head with vertexal protuberance . . . . *Feltiella* (see Gagné 1995)
6\. Head with vertexal protuberance; male flagellomeres with 3 circumfila occasionally interconnected . . . . *Lophodiplosis*
– Head without vertexal protuberance; male flagellomeres with 2 circumfila 7
7\. Palpus 3 segmented, third segment inserted subapically on second; female cerci bilaterally compressed . . . . *Zeuxidiplosis* (see Harris 1966)
– Palpus 3 or 4 segmented, if with only 3, the third segment inserted apically on second; female cerci dorsoventrally compressed 8
8\. Abdominal second through seventh tergites without lateral setae at midlength . . . . *Stenodiplosis* (see Gagné 1994)
– Abdominal tergites with lateral setae at midlength . . . . *Contarinia* (see Harris 1979)

THE SPECIES OF *LOPHODIPLOSIS*

Besides the five new species keyed and described below, two Australian species reported earlier from *Eucalyptus,* a genus close to *Melaleuca,* may also belong to *Lophodiplosis.* These are "*Cecidomyia*" *parilis* Skuse (1888: 87) and "*Cecidomyia*" *eucalypti* Skuse (1890: 381), both described on the basis of superficial characters. "*Cecidomyia*" *parilis* was originally described from a female collected by Skuse from Middle Harbour, New South Wales. This pinned specimen, with abdomen and appendages intact, is in the ANIC and labeled,



Figs. 1–6. Galls of *Lophodiplosis* spp. on *Melaleuca* spp. Figs. 1–2, Blister leaf galls of *L. indentata* on *M. dealbata*: 1, 1x; 2, 6x, leaf in cross section showing larval feeding chamber and exit tube after adult has emerged. Figs. 3–4, Rosette bud gall of *L. bidentata* on *M. quinquevervia*: 3, 1x; 4, 6x, group of larval cells with adjacent modified leaves from center of bud, one cell entire, three with apex dehisced following successful departure of adult (one in x-section), and one with hole made by parasitoid. Figs. 5–6, Trumpet leaf galls of *L. cornuata* on *M. viridiflora*; 5, 1x; 6, 6x, two galls, one in cross section.

"Dipl. parilis, ♀ type, F.A.A. Skuse, Middle Harb., S." Skuse (1890) later identified as this species females bred from leaf blister galls on *Eucalyptus corymbosa* collected by Froggatt at Waverley, near Sydney. The leaf blisters suggest those of *L. indentata* on *Melaleuca.* Four female specimens immediately follow the type of *C. parilis* in the ANIC, each bearing a single label reading, "bred Nov. 20." These may be Froggatt's specimens, but until these and the type are slide mounted, we cannot know whether Froggatt's specimens really belong to "*C.*" *parilis* or even if "*C.*" *parilis* fits in *Lophodiplosis.* "*Cecidomyia*" *eucalypti* known from evidently a single female ("Description drawn from fresh specimen") from Botany, New South Wales, was reared from woody swellings on stems of *Eucalyptus haemastoma.* There is no specimen labelled *eucalypti* in the Skuse collection ANIC.

Another Australian species, "*Cecidomyia*" *frauenfeldi* Schiner (1868: 7) was reared from rosette-like malformations covering the swollen branch buds of a species of *Melaleuca* found at "Naraby Lagoon" [prob. for Narabeen Lagoon per note by Skuse 1888: 62], Port Jackson [Sydney, New South Wales]. The adults were described as having more than 12 flagellomeres, with those of the male stemmed, which indicates they belong to neither *Lophodiplosis* nor *Lasioptera,* the two genera we have found on *Melaleuca.*

KEY TO ADULTS OF *LOPHIDIPLOSIS* SPP. AND *LASIOPTERA* ON *MELALEUCA*

1. R_5 about half wing length (Fig. 58); inquiline or successor in blister galls of *Lophodiplosis indentata* and trumpet galls of *Lophodiplosis cornuata* . . . . *Lasioptera uncinata*
– R_5 reaching costa beyond wing apex (Fig. 11) 2
2. Tarsal claws simple (Fig. 10); male flagellomeres with short, indistinct internodes and circumfilar loops barely longer than wide (Fig. 8) 3
– Tarsal claws toothed (Fig. 24); male flagellomeres with distinct internodes and circumfilar loops much longer than wide (Fig. 21) 4
3. Tarsal claws amber colored; vertexal protuberance elongate with apical and lateral setae (Fig. 7); male circumfila interconnected (Fig. 8); from leaf blister galls . . *Lophodiplosis indentata*
– Tarsal claws dark brown; vertexal protuberance short with only apical setae (Fig. 23); male circumfila not interconnected (as in Fig. 21); from trumpet leaf galls . . . . . *Lophodiplosis cornuata*
4. Tarsal claws dark brown, with 2 teeth (Fig. 24); female eighth tergite with distinct row of setae posteriorly; male cerci triangular (Fig. 25); from bud rosette galls . . *Lophodiplosis bidentata*
– Tarsal claws amber colored, with single tooth (Fig. 18); female eighth tergite with only scattered setae posteriorly; male cerci quadrate or secondarily lobed (Figs. 20, 41) 5
5. Vertexal protuberance elongate with lateral setae (as in Fig. 7); aedeagus shorter than hypoproct (Fig. 20); setae at base of female cerci longer than cerci (as in Fig. 13); from leaf blister galls . . . . *Lophodiplosis denticulata*
– Vertexal protuberance short with only apical setae (as in Fig. 23); aedeagus longer than hypoproct (Fig. 41); setae at base of female cerci much shorter than cerci (Fig. 43); possible inquiline in galls of *Lophodiplosis indentata, Lophodiplosis denticulata,* and *Lophodiplosis bidentata* . . . . *Lophodiplosis trifida*

KEY TO PUPAE OF *LOPHODIPLOSIS* SPP. AND *LASIOPTERA* ON *MELALEUCA*

1. Vertex convex, without protuberance (Fig. 64) . . . . *Lasioptera uncinata*
– Vertex with protuberance (Figs. 44–53) 2
2. Frons without pair of setae anterior to labrum (Figs. 44, 46); vertex with 1 central and 2 much shorter ventral protuberances (Figs. 45, 47) 3
– Frons with pair of setae anterior to labrum; vertex with a single median protuberance that may be divided apically (Figs. 48, 50, 52) 4
3. Vertex with central protuberance tapering to point (Fig. 44) . . . . *Lophodiplosis indentata*
– Vertex with central protuberance cylindrical, concave apically (Fig. 46) . . . .*Lophodiplosis denticulata*
4. Vertex with protuberance shorter than height of antennal bases (Fig. 48, 49) . . . . *Lophodiplosis bidentata*
– Vertex with protuberance much longer than height of antennal bases (Figs. 50, 52) 5
5. Vertex with protuberance conical from base to slightly notched apex (Fig. 50) . . . . *Lophodiplosis cornuata*
– Vertex with protuberance strongly angled for most of length, with three apical points (Fig. 52) . . . . *Lophodiplosis trifida*

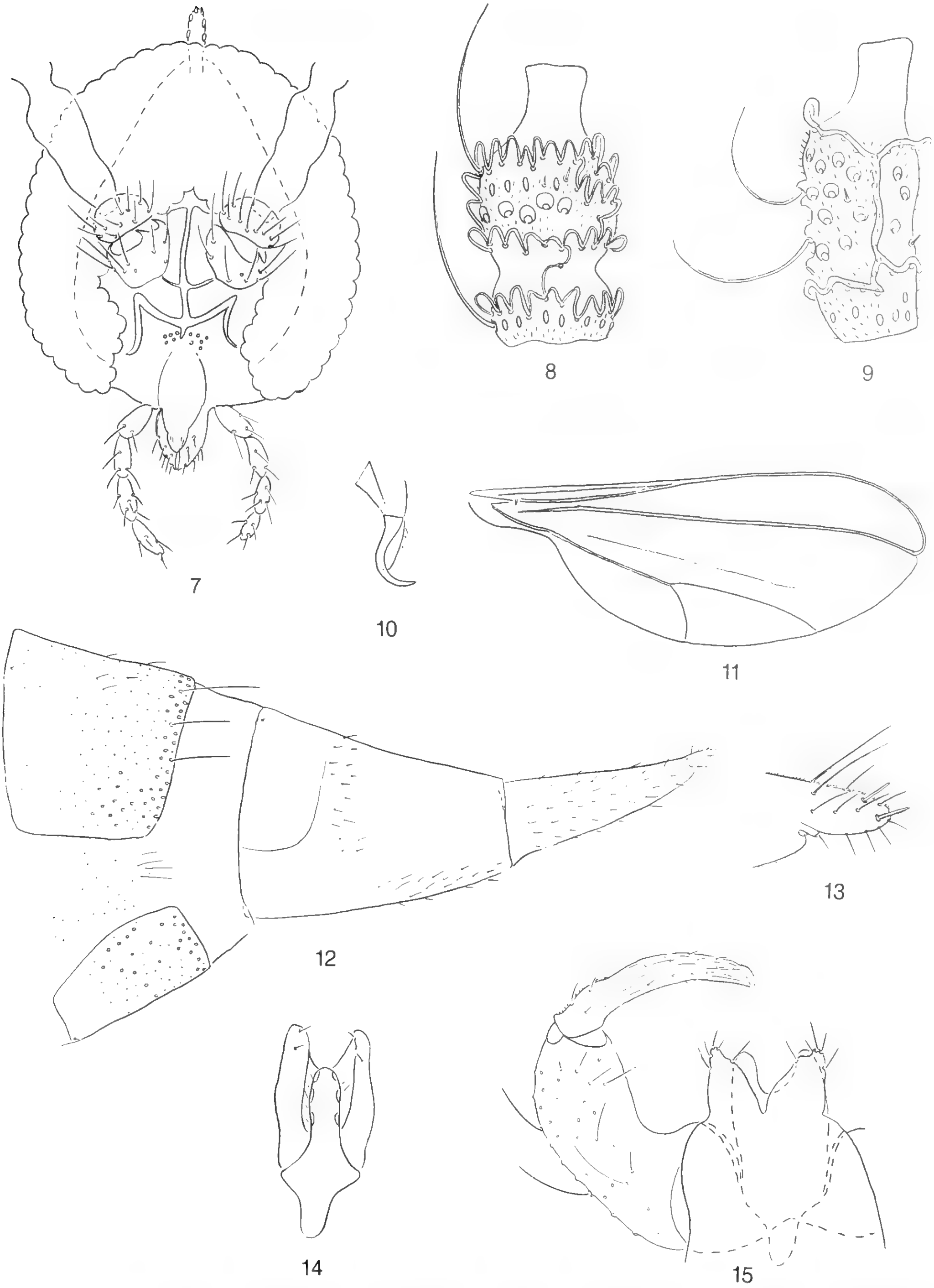
***Lophodiplosis indentata* Gagné, new species**

Figs. 1, 2, 7–17, 44, 45

Adult.—Head (Fig. 7): Vertex with elongate dorsal protuberance bearing 4–5 setae, 2–3 at or near apex, the remainder near midlength. Male flagellomeres (Fig. 8) binodal, internodes very short, necks moderately long, nodes with sparse setulae; circumfila interconnected, bases not on same horizontal plane, loops short. Female flagellomeres (Fig. 9) cylindrical with moderately long necks; circumfila appressed except for short loops at apex.

Thorax: Wing (Fig. 11), length, 1.9–2.3 mm in males (n = 10), 2.5–3.1 mm in females (n = 10); Rs apparent only as spur of R_5, situated closer to arculus than to apex of R_1. Tarsal claws (Fig. 10) amber colored, untoothed.

Male abdomen: First through sixth ter-



Figs. 7–15. *Lophodiplosis indentata.* 7, Male head. 8, Male third flagellomere. 9, Female third flagellomere. 10, Tarsal claw and empodium. 11, Wing. 12, Female postabdomen, seventh segment to end, lateral. 13, Female cerci, detail. 14, Aedeagus and hypoproct, ventral. 15, Male genitalia, dorsal.

gites with mostly single, posterior row of setae, partly double on sixth tergite, with 0–5 lateral setae, and otherwise mostly covered with scattered setiform scales. Seventh tergite with 0–5 dorsolateral setae, 0–several setiform scales mesally, and an anterior pair of trichoid sensilla. Eighth tergite bare except for anterior pair of trichoid sensilla. Genitalia (Figs. 14–15): cerci more or less acute-triangular, with several setae posteriorly; hypoproct bilobed, laterally curving toward venter and nestling aedeagus, with 1–2 pairs of weak setae on posterolateral margins; aedeagus short, cylindrical, tapering slightly to rounded apex, reaching approximately to base of concavity of hypoproct; gonostylus with setulae present only at base.

Female abdomen (Figs. 12–13): First through fifth tergites with mesally single to laterally double, uninterrupted, posterior row of setae, sixth and seventh tergites with mesally double to laterally triple row of setae; third through seventh tergites with increasing number of lateral setae, 3–4 on third to 15–20 on seventh; first through seventh tergites covered with setiform scales; eighth tergite with weak, scattered setae posteriorly and anterior pair of trichoid sensilla; ovipositor short-protrusible, distal half about 1¼ times as long as seventh tergite, with short setae ventrally on intersegmental membrane, ninth segment with evenly distributed setae; tenth tergum without setae; cerci short, bilaterally flattened, closely approximated mesally with several setae, one pair of setiform sensoria, and otherwise covered with setulae; hypoproct entire, longer than wide.

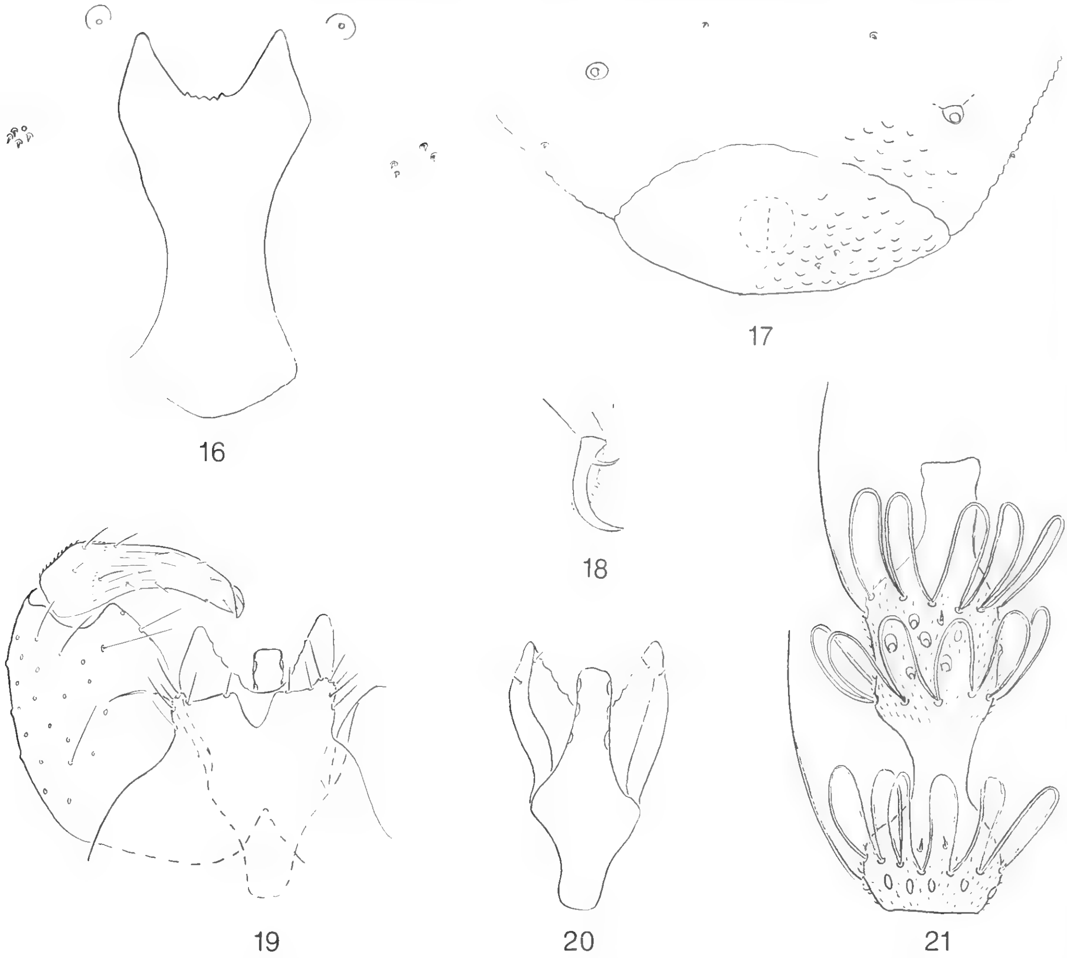
Pupa (Figs. 44–45).—Vertex with one dorsoventrally flattened, pyramidal projection and two shorter, ventral projections. Antennal bases with sharp, transverse, ventral crest. Face without setae or conspicuous protuberance.

Larva.—Third instar (Figs. 16–17): Integument mostly rugose. Spatula with two acutely triangular anterior projections, intervening concavity smooth to minutely dentate, the shaft narrowest at midlength, broadening but less sclerotized posteriorly and ending abruptly at broad base. Lateral papillae on each side of spatula reduced in most specimens to the two setose pairs, occasionally one or both asetose papillae present; dorsal and pleural papillae with setae little longer than wide; terminal papillae reduced to two pairs, with setae slightly longer than wide; anal papillae absent.

Second instar (based on specimen with fully developed third instar inside): Body shape as for third instar but shorter. Otherwise as for third instar including spatula of similar shape.

Holotype.—♂, from blister leaf galls of *M. quinquenervia,* Australia, Queensland, Tully Heads Road #3, 15.3 km ESE Tully, 17-VII-1995, JKB, FSNQMqn95137, deposited in ANIC.

Paratypes.—All specimens from blister leaf galls, Queensland, Australia, most deposited in ANIC, with representatives deposited in the USNM. From *M. quinquenervia*: 2♀, Forrest Beach, 16 km SE Ingham, 6-VII-1987, JKB, NQMqn87073; 1 pupal exuviae, Forrest Beach Swamp, 15.6 km ESE Ingham, 4-X-1994, DWB, FSNQMqn94136; 4 larvae, Forrest Beach Swamp, 15.6 km ESE Ingham, 10-V-1994, J.R. Makinson, FSNQMqn94058; ♂, Cardwell Swamp Site, 2 km SE Cardwell, 31-VIII-1992, em. 8-IX-1992, ADM, FSNQMqn92056; 3 larvae, pupa, Edge Hill, Woodward Park, 4.2 km WNW Cairns GPO, 14-VIII-1994, P. Geyson, NQMqn940 80; 3♀, Centenary Park, Cairns, 3-VIII-1987, JKB, NQMqn87085; larva, Tully Heads Rd #3, 15.3 km ESE Tully PO, 27-VI-1994, JKB, FSNQMqn94094; 5 larvae, Tully Heads Rd #3, 15.3 km ESE Tully PO, 2-VIII-1994, DWB, FSNQMqn94114; 4♂, 3♀, 2 pupal exuviae, Tully Heads Road #3, 15.3 km ESE Tully, 17-VII-1995, JKB, FSNQMqn95137 (19 more ♀ and 7 p. exuv. in alc.; from same lot as L. denticulata); 1 pupal exuviae, Tully Heads Road #3, 15.3 km ESE Tully, 14-VIII-1995, JKB, FBNQMqn95163; 4 larvae, Murrigal Cul-



Figs. 16–21. 16–17, *Lophodiplosis indentata.* 16, Larval spatula and associated papillae. 17, Larval eighth and terminal segments. 18–21, *Lophodiplosis denticulata.* 18, Tarsal claw and empodium. 19, Male genitalia, dorsal. 20, Aedeagus and hypoproct, ventral. 21, Male third flagellomere.

vert, 14.8 km S Tully, 4-X-1994, DWB, FSNQMqn94137; 6 larvae, Murrigal Gravel Pit, 19.3 km S Tully, 2-VIII-1994, DWB, FSNQMqn94112; larva, Bruce Hwy, S of Murrigal, 16 km S Tully, 10-III-1992, ADM, NQMqn92017; 5 larvae, Feluga Site 1, 9.4 km E Tully, 27-VI-1994, JKB, FSNQMqn94092; larva, Bilyana, Double Barrel Creek Swamp, 22 km NE Tully, 10-III-1992, ADM, NQMqn92018; 3 larvae, 3 pupae, Townsville, 21-II-1995, RJG; 3 larvae, Feluga Site 1, 9.4 km E Tully, 26-X-1994, JKB, FSNQMqn94142; 4 larvae, 4 pupae, South Queensland, XI-1995, DWB; 3 larvae, Doolandella, 16 km SSW Brisbane GPO, 30-V-1994, M. Purcell. From *M. dealbata*: 14♂, Cardwell North, 3 kms N Cardwell, 31-VIII-1992, em. 7-25-VII-1992, ADM, DWB, FSNQMdl92057; 2 larvae, Murrigal Culvert, 14.8km S. Tully, 18-IX-1995, DWB, FSNQMdl95188; 2♂, ♀, 2 pupal exuviae, Tully Heads Road #4, 16.9 km ESE Tully, 17-VII-1995, JKB, FSNQMd195135; 2 larvae, Tully Heads Road #4, 16.9 km ESE Tully, 27-III-1995, JKB, FSNQMd195076; 2♂, ♀, 4 pupal exuviae, Murray River Swamp, 12 km S Tully, 14-VIII-1995, JKB, FSQNMdl95159;

♂, 3♀, 4 pupal exuviae, Forrest Beach School, 16 km ESE Ingham, 14-VIII-1995 JKB, FSQNMdl95154. From *M. viridiflora*: 3 larvae, Murrigal section of Bruce Hwy, 19.3 km S Tully, 2-VIII-1994, DWB, FSNQMvr94115; 3♀, 1 pupal exuviae, Feluga Site 1, 9.4 km E Tully, 18-VII-1995, JKB, FSNQMvr95140; ♂, 2♀, 2 pupal exuviae, Feluga Site 1, 9.4 km E. Tully, 15-VIII-1995, DWB, FSNQMvr95165 (in same lot as specimens of *L. denticulata*). From *M. arcana*: 2 larvae, 1 pupal exuviae, Cape Flattery Swamp, 41.1 km N Cooktown, 25-VII-1994, JKB, NQMac94074. From *M. fluviatilis*: 3 larvae, pupa, Charters Towers, 24-II-1995, RJG. From *M. saligna*: larvae, Flying Fox Swamp, 57.2 km WNW Cooktown, 27-VII-1994, JKB, FSNQMsl94109.

Etymology.—The name *indentata* is Latin for "untoothed," with reference to the simple, untoothed tarsal claws of this species.

Gall (Figs. 1–2).—This species forms a leaf blister gall, a convex, occasionally low-conical swelling that shows equally on both surfaces of the leaf. Leaves infested with these galls may be curled and otherwise distorted, especially when the leaf surfaced is completely covered with the galls. One or more larvae may be found in a gall but each larva is in a discrete cell. As the larva matures, the tissue above one end of the gall changes in nature to form a cylindrical passage extending from just outside the larval cell to the abaxial surface epidermis. Pupation occurs in the larval cell. The full-grown pupa pushes its way through a thin, circular cap that develops on the larval cell wall, then proceeds through the tunnel and breaks through the thin leaf epidermis forming the cover of the tunnel and where the pupa lodges itself. The adult then breaks out of the pupa, usually leaving the pupal exuviae caught part way out of the gall exit.

Remarks.—*Lophodiplosis indentata* was commonly reared from leaf blister galls on several species of *Melaleuca* in Queensland, twice in association with *L. denticulata* (q.v.). The gall surface is rounded except on *M. dealbata* where it is usually pointed in the center (Figs. 1–2).

This species shares with *L. denticulata* an exceptionally long adult vertexal projection, the male hypoproct partially enfolding the aedeagus, and the lack of pupal facial setae. It differs from *L. denticulata* in having untoothed tarsal claws, very short flagellomere internodes and shorter, interconnected circumfilar loops, longer male gonopods, and a tapering, pyramidal protuberance on the pupal vertex.

***Lophodiplosis denticulata* Gagné, new species**

Figs. 18–21, 46, 47

Adult.—Head (as for Fig. 7): Vertex with elongate dorsal protuberance bearing 4–5 setae, 2–3 at or near apex, the remainder near midlength. Male flagellomeres (Fig. 21) binodal, internodes and necks moderately long, nodes setulose; circumfila discrete, bases of each on same horizontal plane, loops moderately and uniformly long. Female flagellomeres (as in Fig. 9) cylindrical with moderately long necks; circumfila appressed except for short loops at apex.

Thorax: Wing (as in Fig. 11), length, 1.8–2.3 mm in males (n = 3), 2.2–2.3 mm in females (n = 2); Rs apparent only as a spur off R_5, situated closer to arculus than to apex of R_1. Tarsal claws (Fig. 18) amber colored, with fine basal tooth.

Male abdomen: First through sixth tergites with mostly single, posterior row of setae, sometimes mostly double on sixth tergite, with 0–5 lateral setae, and otherwise mostly covered with scattered setiform scales. Seventh tergite with 0 dorsolateral setae and O-several setiform scales mesally. Eighth tergite bare except for anterior pair of trichoid sensilla. Genitalia (Figs. 19–20): cerci more or less quadrate, longest at posterolateral angle, with several setae posteriorly; hypoproct bilobed, laterally curving toward venter and nestling the aedeagus, with 1–2 pairs of weak setae on posterolateral margins; aedeagus short, cylindrical, tapering slightly to rounded apex, reaching almost to posterior margins of hypoproct; gonostylus with setulae present only at base.

Female abdomen: First through fifth tergites with mesally single to laterally double, uninterrupted, posterior row of setae, sixth and seventh with mesally double to laterally triple row of setae; third through seventh tergites with 3–7 lateral setae; first through seventh tergites otherwise covered with setiform scales; eighth tergite with weak, scattered setae posteriorly and anterior pair of trichoid sensilla; ovipositor similar to that of *L. indentata,* short-protrusible, distal half about 1¼ times as long as seventh tergite, with short setae present ventrally on intersegmental membrane, evenly distributed setae on ninth segment; bare of setae on tenth tergum; cerci short, bilaterally flattened, closely approximated mesally with several setae, each with one pair of setiform sensoria, and otherwise covered with setulae; hypoproct entire, longer than wide.

Pupa (Figs. 46–47).—Vertex with one elongate, cylindrical, ventromesal projection with concave, crenulate apex, and two shorter, ventral projections. Antennal bases with sharp, transverse, ventral crest. Face without setae or conspicuous protuberance.

Larva.—Unknown. If similar to *L. indentata,* specimens of *L. denticulata* may be included among those listed for *L. indentata.*

Holotype.—♂, from blister leaf galls of *M. quinquenervia,* Australia, Queensland, Tully Heads Road site #3, 15.3 km ESE Tully, 17-VII-1995, JKB, FSNQMqn95137, deposited in ANIC.

Paratypes.—All specimens from Queensland, Australia, and from blister galls on *Melaleuca* spp., deposited in ANIC except for one male and three pupal exuviae in USNM: ♂, same data as holotype (both from same lot as *L. indentata*); ♀, *M. quinquenervia,* Edge Hill, Pease St. Park, Cairns, 2-IX-1992, em. by 18-IX-1992, JKB, NQMqn92060; ♂, *M. quinquenervia,* Feluga Site 3, 13 km NE Tully, 31-VIII-1992, em. 6-IX-1992, ADM, FSNQMqn 92058; ♀, 5 pupal exuviae, *M. viridiflora,* Feluga Site 1, 9.4 km E. Tully, 15-VIII-1995, DWB, FSNQMvr95165 (in same lot as specimens of *L. indentata*).

Etymology.—The name *denticulata* is a Latin diminutive for "toothed," with reference to the thin tooth present at the base of the tarsal claws of this species.

Gall.—This species was reared from the swollen leaf blister galls on *M. quinquenervia* and *M. viridiflora* (Figs. 1–2) similar to those attributed here mainly to *L. indentata.* Both species may cause the galls but *L. denticulata* was much less commonly reared.

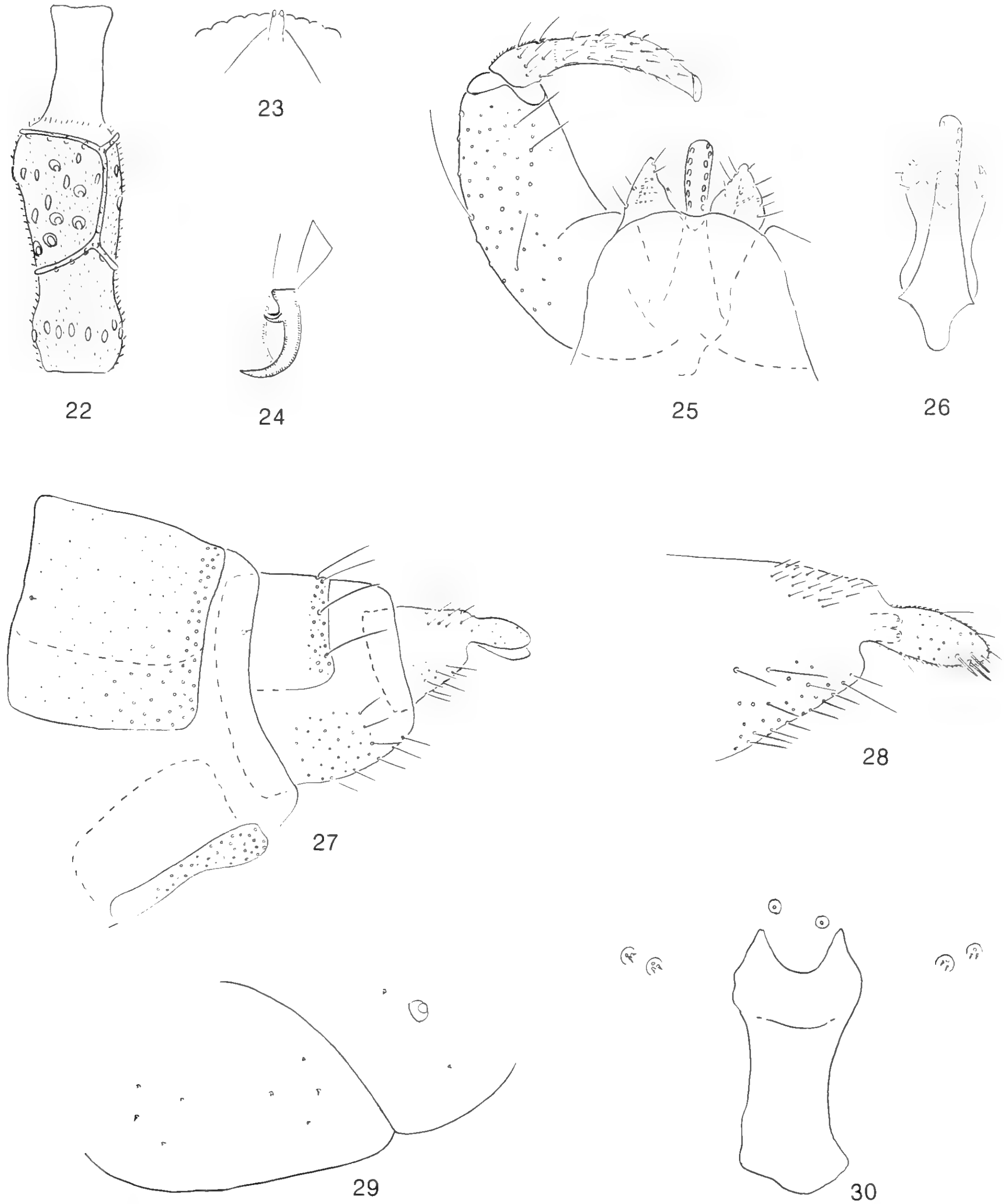
Remarks.—This species shares with *L. indentata* the exceptionally long adult vertexal projection, the male hypoproct partially enfolding the aedeagus, and the lack of pupal facial setae. It differs from *L. indentata* in having toothed tarsal claws, longer flagellomere internodes and longer, discrete, circumfilar loops, shortened male gonopods, and a longer, more cylindrical protuberance on the pupal vertex.

This species was reared four times from leaf blister galls similar to those of *L. indentata,* from four separate localities in northern Queensland and represented by one or two adults each and, in one of those cases, by five pupal exuviae. In two of those collections, *L. denticulata* was found in association with *L. indentata.* Larvae, if similar to those of *L. indentata,* may be mistakenly listed under that species. We can offer no speculation for why these closely related species occupy similar galls on the same hosts and at the same sites.

Lophodiplosis bidentata Gagné, new species

Figs. 3, 4, 22–30, 48, 49

Adult.—Head: Vertex with short dorsal protuberance bearing 2 setae at or near apex (Fig. 23). Male flagellomeres (similar to that of *L. denticulata,* Fig. 21) binodal, internodes and necks moderately long; cir-



Figs. 22–30. *Lophodiplosis bidentata.* 22, Female third flagellomere. 23, Vertexal projection. 24, Tarsal claw and empodium. 25, Male genitalia, dorsal. 26, Aedeagus and hypoproct, ventral. 27, Female postabdomen, seventh segment to end, lateral. 28, Female ninth segment to end, detail. 29, Larval eighth and terminal segments. 30, Larval spatula and associated papillae.

cumfila discrete, bases of each on same horizontal plane, loops moderately and uniformly long. Female flagellomeres (Fig. 22) with nodes slightly constricted near basal third, necks elongate.

Thorax: Wing length, 2.4–2.6 mm in

males (n = 4), 3.0–3.2 mm in females (n = 4); Rs situated closer to arculus than to apex of R_1. Tarsal claws (Fig. 24) dark brown, with two basal teeth, the proximal tooth finer.

Male abdomen: First through sixth tergites with mostly single, but double laterally, posterior row of setae, mostly double row on sixth tergite, all with 3–5 lateral setae. Seventh tergite with 3–5 dorsolateral setae, and 0–3 scales posterolaterally. Eighth tergite bare except for anterior pair of trichoid sensilla. Genitalia (Figs. 25–26): cerci triangular, laterally curved ventrally, with several setae along margin; hypoproct bilobed, with several scattered pairs of setae ventrally; aedeagus longer than hypoproct, tapering gradually from base to midlength and widening slightly beyond to rounded apex, with rows of several papillae; gonostylus with setulae present on basal fourth.

Female abdomen (Figs. 27–28): First through fifth tergites with mostly double posterior row of setae, sixth and seventh with triple row of setae; third through seventh tergites with increasing number of lateral setae, 3–4 on third to 10 on seventh; eighth tergite with a mostly double posterior row of strong setae mixed with setiform scales and anterior pair of trichoid sensilla; ovipositor short-protrusible, distal half about ½ times as long as seventh tergite, with many setae present laterally and ventrally on intersegmental membrane and ventrally on ninth segment; tenth tergum covered laterally with setae; cerci ovoid, bilaterally flattened, closely approximated mesally, with several setae, each with 3–4 setiform sensoria, and otherwise covered with setulae; hypoproct broad, deeply bilobed.

Pupa (Figs. 48–49).—Vertex with short, ventral, triangular, dorsoventrally flattened, slightly notched projection. Antennal bases simply rounded. Face with pair of setae anterior to labrum, without protuberance.

Larva.—Third instar (Figs. 29–30): Integument mostly smooth. Spatula with two acutely triangular anterior projections, the shaft narrowest at midlength, broadening posteriorly and ending abruptly at broad base. Lateral papillae in two groups of three on each side of spatula, 2 of each group with seta, the other without; dorsal and pleural papillae with setae not longer than papilla base; terminal segment with 4 papillae on each side, the setae all tiny but one on each side slightly longer than remainder.

Second instar: Body shape as for third instar but shorter. Otherwise as for third instar except spatula smaller and not sclerotized posteriorly.

Holotype.—♂, from rosette galls of *M. quinquenervia,* Australia, Queensland, Feluga site #1, 9.4 km E Tully, 15-VIII-1995, DWB, FSNQMqn95166, deposited in ANIC.

Paratypes.—All specimens from *M. quinquenervia,* Queensland, Australia, most deposited in ANIC, with representatives deposited in USNM: 2♂, 3♀, 2 pupal exuviae, Feluga site #1, 9.4 km E Tully, 15-VIII-1995, DWB, FSNQMqn95166; 2 larvae, Feluga Site #1, 9.4 km E Tully, 27-VI-1994, JKB, FSNQMqn94042; pupa, larva, Feluga Site #1, 9.4 km E Tully, 26-X-1994, JKB, FSNQMqn94142; 2♂,1♀, Feluga site #1, 9.4 km E Tully, 18-VII-1995, JKB, FSNQMqn95139; 1 pupa, Feluga site #1, 9.4 km E Tully, 10-XII-1993, DWB, FSNQMqn93084; 2 larvae, Tully Heads Road #3, 15.3 km ESE Tully PO, 27-VI-1994, JKB, FSNQMqn94094; ♂, Tully Heads Road #3, 15.3 km ESE Tully PO, 22-II-1995, RJG; pupa, Murrigal Gravel Pit, 19.3 km S Tully, 28-III-1995, JKB, FBNQMqn95086; 3 pupae, Murrigal Section of Bruce Hwy, 19.3 km S Tully, 11-V-1993, JKB, NQMqn93025; pupa, larva, 16 km ESE Ingham, Forrest Beach Swamp, 15.6 km ESE Ingham, 2-VIII-1994, DWB, FSNQMqn94110.

Etymology.—The name *bidentata* is Latin for "two toothed," with reference to the two teeth present at the base of the tarsal claws of this species.

Gall (Figs. 3–4).—The gall made by this

species is made up of a hard, ovoid larval cell closely surrounded by modified leaves. Many separate galls may occur in aggregate on a single bud. Galls develop on terminal or lateral buds and cause a foreshortening of the branch so that all the leaves around the gall form a rosette. These galls stunt the surrounding leaves and prevent normal branch elongation where they occur. Pupation occurs in the gall. At that time a circular, weakened area develops at the apex of the cell. The fully developed pupa pushes about half way through the trap door where it lodges. The adult then breaks out of the pupa.

Remarks.—*Lophodiplosis bidentata* is distinct from the other species of *Lophodiplosis* in having two teeth at the base of each tarsal claw, triangular male cerci and narrow hypoproct, a short ovipositor with more than a pair of setiform sensoria on the cerci and a two-lobed hypoproct, and a short, dorsoventrally compressed protuberance on the pupal vertex.

***Lophodiplosis cornuata* Gagné, new species**

Figs. 5, 6, 31–38, 50, 51

Adult.—Head: Vertex with short dorsal protuberance bearing 2 apical or subapical setae, placed at or near apex. Male flagellomeres (Fig. 31) only weakly binodal with very short internode but long neck; 1 circumfilum on basal node, 2 on distal node, all with very short loops. Female flagellomeres (Fig. 32) cylindrical with moderately long necks; circumfila appressed.

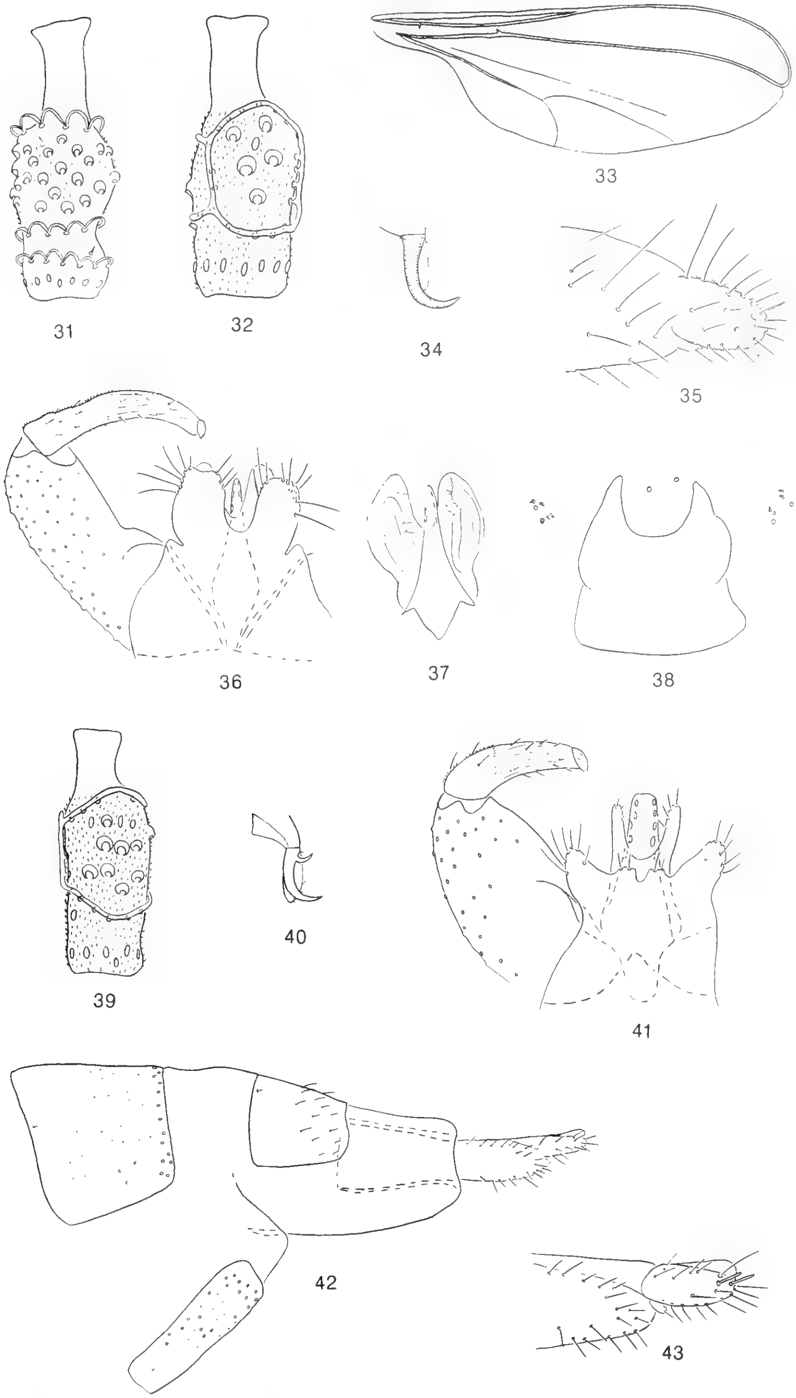
Thorax: Wing (Fig. 33), length, 2.6–2.8 mm in males (n = 4), 2.8–3.2 mm in females (n = 4); Rs apparent only as spur of R_5, situated closer to apex of R_1 than to arculus. Tarsal claws (Fig. 34) dark brown, untoothed; empodia almost reaching bend in claws.

Male abdomen: First through sixth tergites with mostly single, sometimes double laterally, posterior row of setae, sometimes mostly double row on sixth tergite, with 3–6 lateral setae. Seventh tergite with 3–6 dorsolateral setae, several setiform scales mesally. Eighth tergite bare except for anterior pair of trichoid sensilla. Genitalia (Figs. 36–37): cerci rounded to blunt posteriorly, with several prominent lateral and mesal setae; hypoproct deeply lobed, bulging ventrally, more or less nestling aedeagus, with several pairs of weak setae ventrally; aedeagus shorter than hypoproct, cylindrical, tapering from base to narrow apex; gonostylus with setulae present on basal half.

Female abdomen: First through fifth tergites with mesally single to laterally double, uninterrupted, posterior row of setae, sixth and seventh with mesally double to laterally triple row of setae; third through seventh tergites with increasing number of lateral setae, 3–4 on third to 15–20 on seventh; eighth tergite shorter, narrower, and more weakly sclerotized than preceding, with scattered weak posterior setae and anterior pair of trichoid sensilla; ovipositor short-protrusible, distal half about 1¼ times as long as seventh tergite, with short setae ventrally on intersegmental membrane, evenly distributed setae on ninth segment; tenth tergum without vestiture; cerci (Fig. 35) short, bilaterally flattened, closely approximated mesally with several setae, those at base no longer than cerci, each with one pair of setiform sensoria, and otherwise covered with setulae; hypoproct as wide as long.

Pupa (Figs. 50–51).—Vertex conical, more bulbous basally, tapering near mid-length to dorsoventrally flattened, apically notched and slightly recurved apex. Antennal bases simply rounded. Face with pair of setae mesally and without conspicuous protuberance.

Larva.—Third instar: Integument completely rugose. Spatula (Fig. 38) with two acutely triangular anterior projections, the shaft very short. Lateral papillae in two groups of three on each side of spatula, 2 of each group with setae, the third without; dorsal and pleural papillae with setae not longer than papilla bases; terminal segment



Figs. 31–43. 31–38, *Lophodiplosis cornuata.* 31, Male third flagellomere. 32, Female third flagellomere. 33, Wing. 34, Tarsal claw and empodium. 35, Female apex of ninth abdominal segment and cerci, lateral. 36, Male genitalia, dorsal. 37, Aedeagus and hypoproct, ventral. 38, Larval spatula and associated papillae. 39–43, *Lophodiplosis trifida.* 39, Female third flagellomere. 40, Tarsal claw and empodium. 41, Male genitalia, dorsal. 42, Female postabdomen, seventh segment to end, lateral. 43, Female apex of ninth abdominal segment and cerci, lateral.

with undetermined number of convex papillae with short setae.

Holotype.—♂, from trumpet-shaped leaf galls of *M. viridiflora* Australia, Queensland, Magnetic I., 5-III-1995, RJG, deposited in ANIC. Paratypes.—All specimens from trumpet-shaped leaf galls, Queensland, Australia, most deposited in ANIC, with representatives deposited in USNM: 3♂, 3♀, 3 pupal exuviae, on *M. viridiflora,* Magnetic I., 5-III-1995, RJG; 2♀, 7 pupal exuviae, on *M. viridiflora,* 16 km ESE Ingham, Forrest Beach School, 14-VIII-1995, JKB, FSNQMvr94154; 2 larvae, *M. nervosa,* Angus Smith Drive, Townsville, 21-III-1995, DWB.

Etymology.—The name *cornuata* is Latin for "hornlike" with reference to the shape of the gall that suggests the end of a trumpet.

Gall (Figs. 5–6).—This species forms a trumpet shaped gall on the abaxial leaf surface of *M. viridiflora* and *M. nervosa.* Pupation occurs in the gall. The pupa breaks out of the apex of the gall and becomes lodged in the aperture, whereupon the adult emerges from the pupa.

Remarks.—This species is distinct from the other species of *Lophodiplosis* in the inconspicuous internode and short circumfila of the male antenna, the simple, dark brown tarsal claws, the shape of the male genitalia, and the large, slightly recurved, conical vertexal pupal protuberance.

Lophodiplosis trifida Gagné, new species

Figs. 39–43, 52, 53

Adult.–Head: Vertex with short dorsal protuberance bearing 2 setae near apex. Male flagellomeres (as in Fig. 21) binodal, internodes and necks moderately long, nodes setulose; circumfila discrete, bases of each on same horizontal plane, loops moderately and uniformly long but not reaching base of next node or circumfilum. Female flagellomeres (Fig. 39) cylindrical with moderately long necks; circumfila appressed.

Thorax: Wing (as in Fig. 11), length, 2.0 mm in males (n = 1), 2.2–2.3 mm in females (n = 5); Rs apparent only as spur of R_5, situated closer to arculus than to apex of R_1. Tarsal claws (Fig. 40) amber colored, toothed.

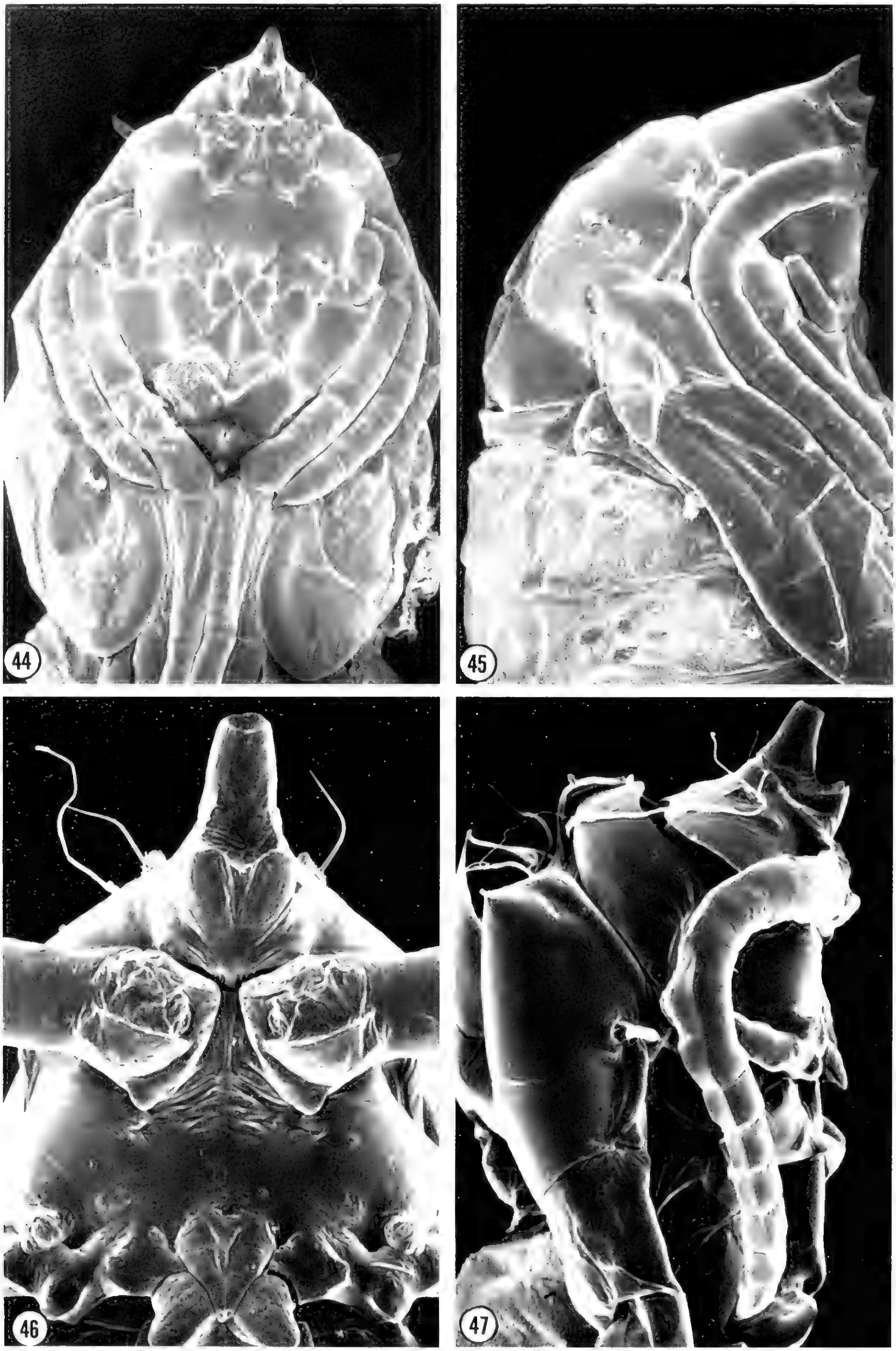
Male abdomen: First through sixth tergites with mostly single, uninterrupted, posterior row of setae, and 2–6 lateral setae. Seventh tergite with 2–5 dorsolateral setae and several setiform scales. Eighth tergite bare except for anterior pair of trichoid sensilla. Genitalia (Fig. 41): cerci barely divided mesally, with short mesoposterior lobe and longer more or less triangular lateroposterior lobe, both lobes setose; hypoproct deeply lobed, the two lobes narrow and elongate, setose posteriorly; aedeagus elongate, longer than hypoproct lobes, tapering gradually from base to blunt apex; gonostylus with setulae present on basal third.

Female abdomen (Figs. 42–43): First through fifth tergites with mesally single to laterally double, uninterrupted, posterior row of setae, sixth and seventh with mesally double to laterally triple row of setae; third through seventh tergites with increasing number of lateral setae, 3–4 on third to 15–20 on seventh; eighth tergite with weak posterior setae and anterior pair of trichoid sensilla; ovipositor short-protrusible, distal half about 1¼ times as long as seventh tergite, with scattered setae ventrally on intersegmental membrane; setae evenly distributed on ninth segment; tenth tergum without setae; cerci elongate-ovoid, each with one pair of setiform sonsoria; hypoproct entire, longer than wide.

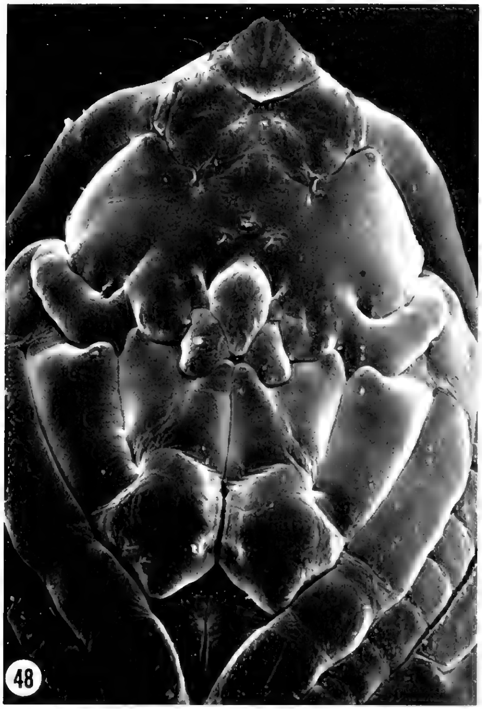
Pupa (Figs. 52–53).—Vertex with elongate mesal projection, deeply angled along entire length, three-pointed apically. Antennal bases each with ventral, conical horn. Face with two horns anteriorly near base of antennae and with pair of setae near middle.

Larva.—Unknown.

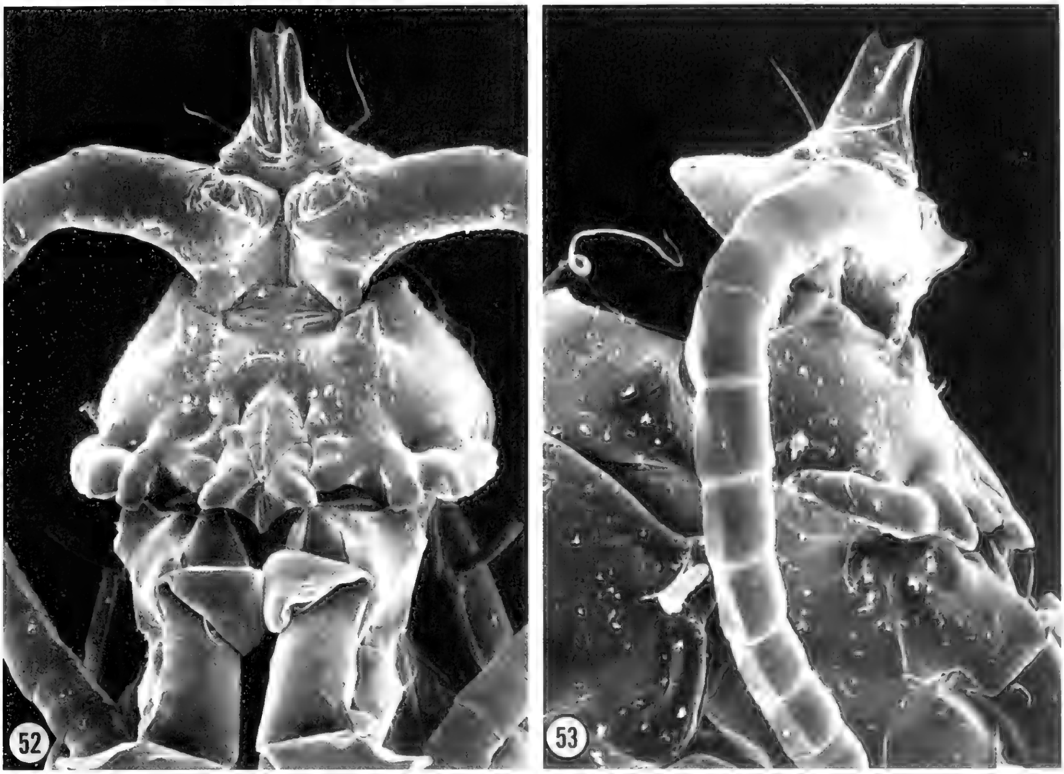
Holotype.—♂, from blister leaf galls of *M. quinquenervia,* Australia, Queensland, Tully Heads Road #3, 15.3 km ESE Tully, 17-VII-1995, JKB, FSNQMqn95137, deposited in ANIC.



Figs. 44–47. Pupae or pupal exuviae of *Lophodiplosis* spp. 44, *L. indentata*, ventral. 45, Same, lateral. 46, *L. denticulata*, ventral. 47, Same, lateral.



Figs. 48–51. Pupae or pupal exuviae of *Lophodiplosis* spp. 48, *L. bidentata*, ventral. 49, Same, lateral. 50, *L. cornuata*, ventral. 51, Same, lateral.



Figs. 52–53. Pupal exuviae of *Lophodiplosis trifida*. 52, Ventral. 53, Same, lateral.

Paratypes.—All specimens from Queensland, Australia, and from blister galls or rosette bud galls on *Melaleuca* spp., deposited in ANIC except for one male and 2 pupal exuviae in USNM: ♂, same data as holotype (both from same lot as *L. indentata* and *L. denticulata*); 4♀, 2 pupal exuviae, blister galls on *M. dealbata,* Tully Heads Road #4, 16.9 km ESE Tully, 17-VII-1995, JKB, FSNQMd195135 (from same lot as *L. indentata*); ♂, 2 ♀, 2 pupal exuviae, from rosette galls on *M. quinquenervia,* Feluga site 1, 9.4 km E Tully, 18-VII-1995, JKB, FSNQMqn95139 (in same lot as *L. bidentata*).

Etymology.—The name *trifida* is Latin for three-cleft, with reference to the three-pointed projection of the pupal vertex.

Gall.—This species is presumably an inquiline and was reared from leaf blister galls with *L. indentata* and *L. denticulata* on *M. quinquenervia* and *M. dealbata,* and from bud rosette galls with *L. bidentata* on *M. quinquenervia.*

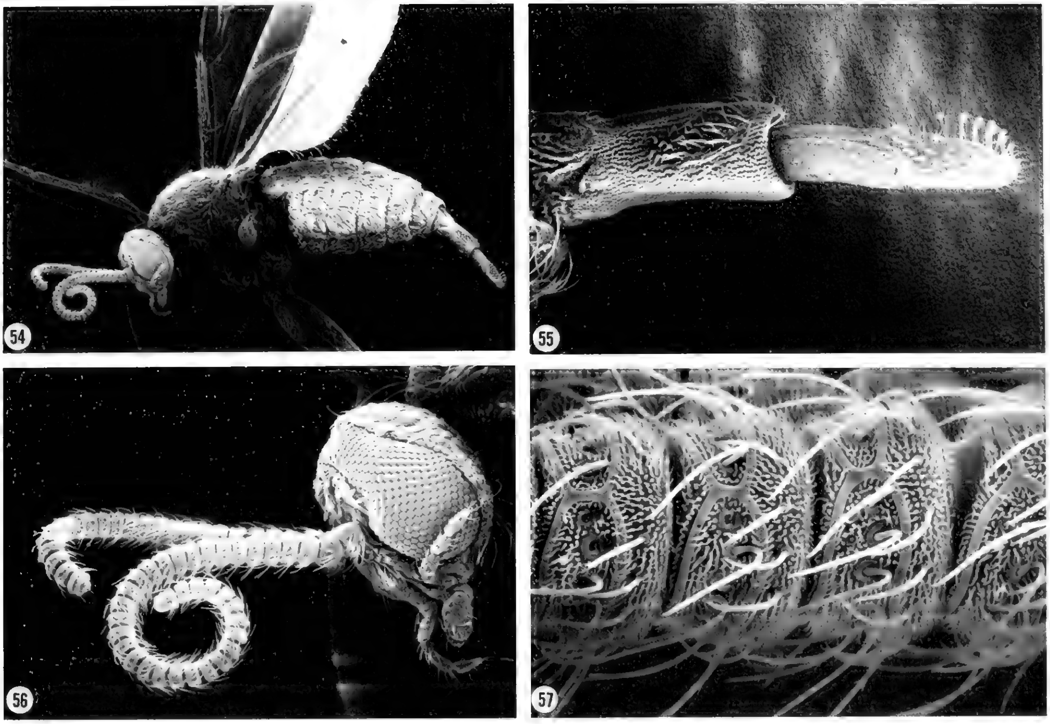
Remarks.—*Lophodiplosis trifida* is distinct from the other species of *Lophodiplosis* for the secondarily divided lobes of the male cerci, the deeply divided male hypoproct, and the large antennal and facial horns and long, three-cleft vertexal protuberance of the pupa.

***Lasioptera uncinata* Gagné, new species**

Figs. 54–64

Adult.—Head (Fig. 56–57): Antenna with pedicel slightly wider than flagellomeres, first and second flagellomeres connate; male with 16–19 flagellomeres, slightly longer than wide; female (Fig. 57) with 31–33 flagellomeres, wider than long. Palpus 4 segmented. Labella elongate ovoid, with strong lateral setae.

Thorax: Wing (Fig. 58), 1.3–1.5 mm long; R_5 0.50–0.54 length of wing (n = 5).

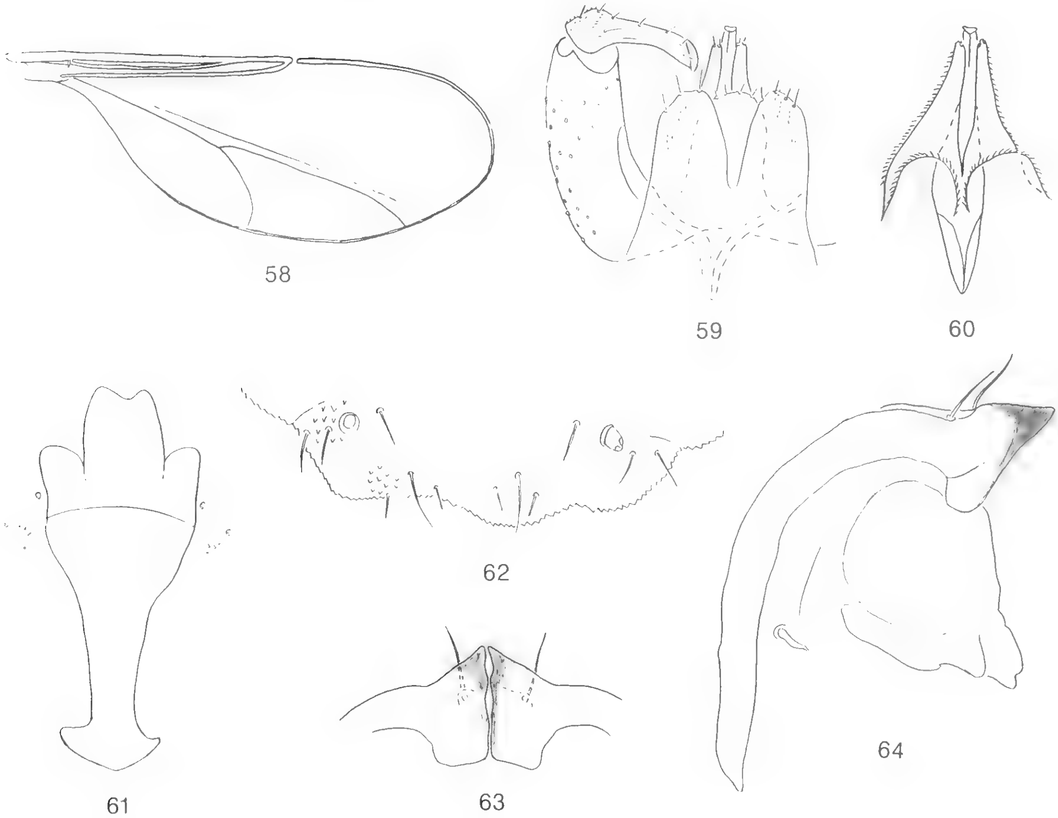


Figs. 54–57. *Lasioptera uncinata.* 54, Head, thorax, and abdomen. 55, Female postabdomen, eighth segment to end. 56, Head. 57, Part of flagellum.

Scutum with two lateral and two dorsocentral rows of setae, otherwise completely covered with scales; scutellum with group of setae on each side, elsewhere covered with scales; anepisternum with scales on dorsal two-thirds; mesepimeron with row of setae and covered with scales; katepisternum with scales in center. Tarsal claws with large basal tooth; empodia as long as claws; pulvilli about ⅔ as long as empodia.

Male abdomen: First through seventh sclerites rectangular with single, uninterrupted row of setae, a pair of anterior trichoid sensilla, and covered with scales; eighth tergite developed only on anterior half, without posterior sclerotization and setae, and otherwise as for preceding tergite except smaller. Genitalia (Figs. 59–60): gonocoxite cylindrical; gonostylus abruptly tapered beyond base, setulose on bulbous base, ridged beyond; cerci convex posteriorly, with ventral and apical setae; hypoproct wide, convex posteriorly, with apical setae; parameres narrow and tapering beyond anterodorsal lobe; aedeagus narrow, as long as gonocoxite.

Female abdomen (Figs. 54–55): First through seventh tergites generally as for male but seventh somewhat smaller in extent; eighth tergum with 2 discrete, elongate sclerites, each with trichoid sensilla near anterior third and several setae posteriorly. Eighth segment with setation only on tergum; intersegmental membrane with lateral group of elbowed setae on each side, with no other setation; ninth segment and cerci about 4.25 times as long as sixth tergite, with setae only posteroventrally and posterolaterally; fused cerci with dorsolateral, glabrous, saddle-shaped area bearing wide, straight setae anteriorly and two posterodorsal rows of uncinate setae continuing to slightly hooked apex of cerci; remaining, setulose area of cerci with fine, thin ventral setae ventrally and thicker, curved, posterior setae.



Figs. 58–64. *Lasioptera uncinata.* 58, Wing. 59, Male genitalia, dorsal. 60, Parameres and aedeagus, dorsal. 61, Larval spatula and associated papillae. 62, Eighth and terminal segments of larva, dorsal. 63, Pupal antennal horns and vertex, ventral. 64, Pupal head and prothoracic spiracle, lateral.

Pupa (Figs. 63–64).—Vertex concave, the 2 setae elongate. Antennal bases pointed and bilaterally flattened apicoventrally. Face without prominences or setae.

Larva tentatively associated with this species (Figs. 61–62).—Spatula large, especially area anteriad of lateral papillae, tridentate anteriorly, the middle tooth the longest and notched. Sternal and ventral papillae of prothorax without setae; with a group of 4 lateral papillae on each side of spatulae, 2 of each group with short seta. Terminal segment with 3 pairs of papillae, setae of one pair twice as long as remaining two.

Holotype.—♀, from blister galls on *M. dealbata,* Australia, Queensland, 3 km N Cardwell, 31-VIII-1992, em. IX-1992, DWB, NQMdl92057, deposited in ANIC.

Paratypes.—All specimens from leaf blister or trumpet-shaped leaf galls on *Melaleuca* spp., Queensland, Australia, most deposited in ANIC, with representatives deposited in USNM: 2♂, from blister galls on *M. dealbata,* 3 km N Cardwell, 31 VIII-1992, em. IX-1992, DWB, NQMdl92057; 2♂ from blister galls *M. quinquenervia,* blister galls, Cardwell Swamp Site, 2 km SE Cardwell, 31-VIII-1992, emerged 14-IX-1992, ADM, FSNQMqn92056; ♂, blister galls, *M. quinquenervia,* Feluga Site 1, 31-VIII-1992, em. 3-IX-1992, Mqn920 59, ADM; 2♀, 4 pupal exuviae, from trumpet-shaped leaf galls, *M. viridiflora,* 16 km ESE Ingham, Forrest Beach School, 14-VIII-1995, JKB, FSNQMvr94153; 2♀, from trumpet-shaped leaf galls, *M. viridiflora,* Magnetic I., Townsville, 5-III-1995, RJG; 2 larvae, from swollen stem, *M. leucadendra,* Oonoonba McPherson St., Townsville, 5-V-1994, L.M. Brown, 94049.

Etymology.—The name *uncinata* is Latin for "hooked," with reference to the hooked setae on the female cerci. These hooks are characteristic of all *Lasioptera* species except for a few species in which they are secondarily lost.

Gall.—This species may be an inquiline or a successor. The latter term is used for species that live in a gall after the gall maker has flown. At least one species of *Lasioptera* is known to have that habit (Yukawa and Haitsuka 1994). *Lasioptera uncinata* was reared from leaf blister galls of *Lophodiplosis indentata* on *M. quinquenervia* and *M. dealbata* and from trumpet leaf galls of *Lophodiplosis cornuata* on *M. viridiflora.*

Remarks.—The larva referred to this species is only tentatively placed here, but fits *Lasioptera* and most other Lasiopterini with its four papillae on each side of the spatula.

Two Australian species of *Lasioptera* were described earlier from *Melaleuca* and *Eucalyptus. Lasioptera nodosae* Skuse (1888:130) was based on a female bred from deformed buds of *Melaleuca nodosa* found in November by Masters in Homebush, NSW, and *Lasioptera miscella* Skuse (1890: 388) bred from malformed, coalescent leaf-stalks of *Eucalyptus haemastoma* in November and collected in Botany, NSW. Peter Kolesik of the University of Adelaide, who is undertaking a revision of the Skuse Cecidomyiidae, kindly compared a photo of the cerci of *L. uncinata* with those of females of both Skuse species and has determined for us that the hooked setae of the new species are distinct in the number and position from those of the other species.

ACKNOWLEDGMENTS

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A NEW GENUS AND SPECIES BELONGING TO THE SUBFAMILY STERICTIPHORINAE (HYMENOPTERA: SYMPHYTA: ARGIDAE) FROM JAPAN

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Abstract.—***Aproceroides sakuraii*, New Genus, New Species,** is described from Japan. The genus is separated from related genera of Sterictiphorinae, and a key is given to the genera of Sterictiphorinae from Japan.

Key Words: Symphyta, Sterictiphorinae, *Aproceroides*

In this paper, I describe a new genus and new species of the argid subfamily Sterictiphorinae from Japan. A revised key to the Japanese genera of the subfamily will separate this new genus from other genera. The holotype is deposited in the collection of the National Science Museum (Natural History), Tokyo.

Aproceroides Togashi, new genus

Robust. Head from above transverse (Fig. 2); eyes slightly converging below (Fig. 1); space between antennal sockets narrow, with a longitudinal ridge in middle (Fig. 1); malar space broad (Fig. 1); clypeus nearly truncate (Fig. 1); labrum small; cenchri large. Forewing: apical portion of costa clearly swollen (Fig. 3); first cubital cross vein absent (Fig. 3); third cubital cross vein curved; basalis joining subcosta at a distance removed from begining of cubitus nearly equal to length of first cubital cross vein; anal cell of forewing broadly constricted in middle with small basal anal cell. Hindwing: analis short, not connected with brachius, with open anal cell (Fig. 4). Legs: tarsal claw simple.

Type species: Aproceroides sakuraii sp. nov.

This new genus is very closely allied to the genus *Sterictiphora* Billberg, but it is easily distinguished from the latter by the presence of the short analis in hindwing and open anal cell (in *Sterictiphora,* the analis of the hindwing is complete and connected with the brachius, with a closed anal cell), and by the swollen apical portion of the costa of forewing (in *Sterictiphora,* the apical portion of costa is not swollen).

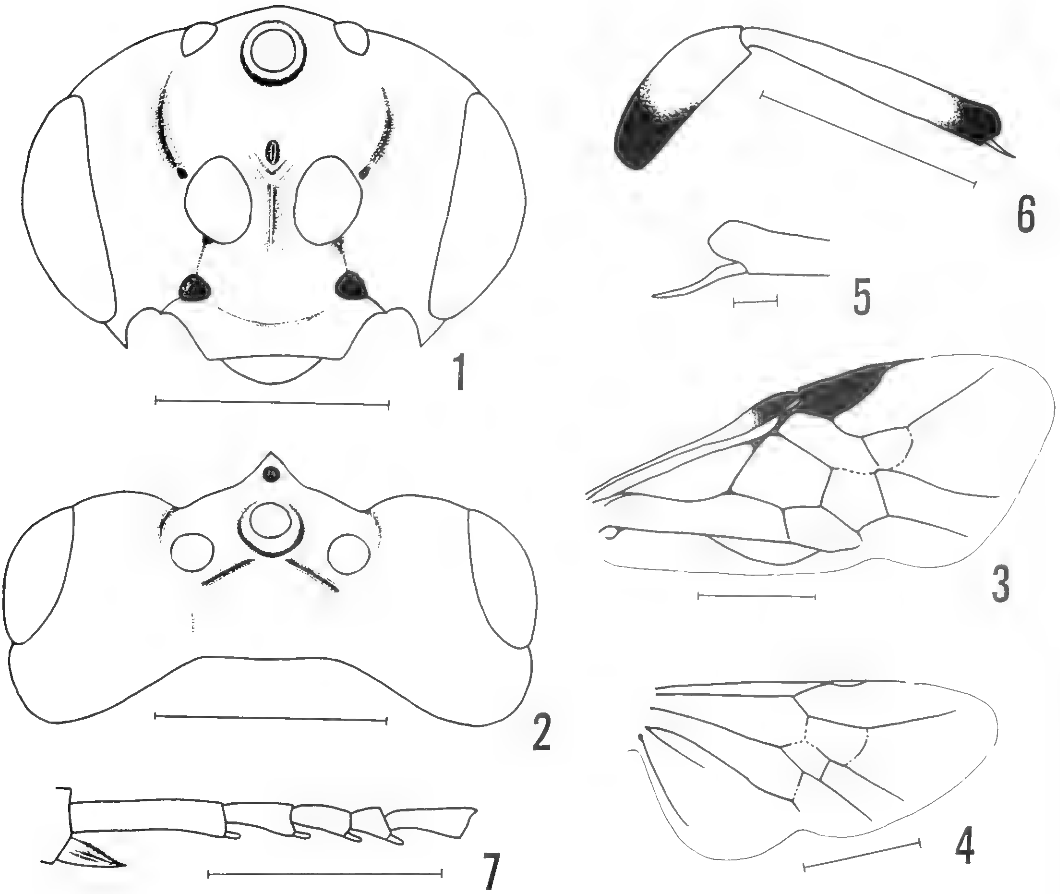
From the genus *Aproceros* Malaise, it is at once distinguished by the broadly contracted anal cell of forewing (in *Aproceros,* the anal cell of forewing is petiolate without a basal anal cell).

From the genus *Yasumatsua* Togashi, it is easily separable by the simple tarsal claw (in *Yasumatsua,* the tarsal claw has a basal lobe).

Aproceroides sakuraii Togashi, new species

(Japanese name: Sakurai-kuwagata-habachi)
(Figs. 1–7)

Male.—Length 4 mm. Body black, with following parts yellow: latero-posterior portion of pronotum and tegula, and following parts dirty yellow: labrum, maxillary and labial palpi, and propodeum. Wings hyaline, basal ¾ of costa of forewing pale yel-



Figs. 1–7. *Aproceroides sakuraii.* 1, Head, front view. 2, Head, dorsal view. 3, Forewing. 4, Hindwing. 5, Inner front tibial spur, lateral view. 6, Hind femur and tibia, lateral view. 7, Hind tarsus, lateral view. Scale: 0.5 mm for Figs. 1, 2, and 7; 0.1 mm for Fig. 5; 1.0 mm for Figs. 3, 4, and 6.

low, apical ¼ of costa, stigma and other veins brownish black to black. Legs yellow but all coxae and trochanters black, basal half of all femora brownish black, apical portion of hind tibiae and all tarsi brownish black.

Head: 00L:P0L:0CL = 0.9:1.0:0.7; postocellar area convex; postocellar furrow distinct but interrupted in middle (Fig. 2); lateral furrows slightly depressed; circumocellar furrow distinct (Fig. 2); frontal area gently convex; median fovea ellipsoidal in form, deep, with a median longitudinal furrow (Fig. 1); lateral foveae distinct; supraclypeal area convex; clypeus narrow; malar space broad, nearly as long as ½ diameter of front ocellus (ratio about 1.0:2.0).

Thorax: Normal. Wings: venation of forewing as in Fig. 3; hindwing with 2 middle cells; analis of hindwing short, not connected with brachius, with open anal cell (Fig. 4). Legs: hind basitarsus as long as following 3 segments combined (ratio about 1.0:1.0); inner hind tibial spur broad (Fig. 7), and slightly shorter than ½ length of hind basitarsus (ratio about 1.0:2.3); inner front tibial spur longer than apical width of front tibia (ratio about 1.0:0.5) (Fig. 5).

Abdomen: Normal.

Punctures.—Head and thorax nearly impunctate, shining. Abdominal tergites nearly impunctate.

Female.—Unknown.

Food plant.—Unknown.

Habitat.—Japan (Honshu).

Holotype: Male; April 17, 1994; Ameya, Aizuwakamatsu City, Fukushima Pref., S. Sakurai leg.

KEY TO THE GENERA OF JAPANESE STERICTIPHORINAE

1. Tarsal claws simple 2
– Tarsal claws with a basal lobe at base; anal cell of forewing petiolate; hindwing with a closed anal cell . . . . *Yasumatsua* Togashi
2. Anal cell of forewing petiolate without a basal anal cell; basalis of forewing joins subcosta at a point much closer to the origin of cubitus than length of first cubital cross vein . . . . *Aproceros* Malaise
– Anal cell of forewing broadly constricted in the middle, with basal anal cell; basalis of forewing joins subcosta at a distance removed from the begining of cubitus that is a little longer than the length of first cubital cross vein (Fig. 3) 3
3. Hindwing with a closed anal cell (analis vein connected to brachius); apex of costa of forewing not swollen . . . . *Sterictiphora* Billberg
– Hindwing with open anal cell (Fig. 4) (analis vein not connected to brachius); apical portion of costa of forewing swollen (Fig. 3) . . . . *Aproceroides,* n. gen.

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THE GENUS *CARPOMYA* COSTA (DIPTERA: TEPHRITIDAE): NEW SYNONYMY, DESCRIPTION OF FIRST AMERICAN SPECIES, AND PHYLOGENETIC ANALYSIS

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Abstract.—***Carpomya tica*, new species,** from Costa Rica is described and reported as the first species of *Carpomya* from the Americas. Phylogenetic relationships within *Carpomya* are analyzed. *Myiopardalis* Bezzi and *Goniglossum* Rondani are recognized as subjective junior synonyms of *Carpomya. Carpomya wiedemanni,* n. comb., and *C. pardalina* (originally described in *Carpomya*) are transferred to *Carpomya* from *Goniglossum* and *Myiopardalis,* respectively, and *Spilographa caucasica* Bigot is removed from the genus. A lectotype is designated for *C. pardalina,* and a key to the species of *Carpomya* is provided.

Resumen.—Se describe ***Carpomya tica*, especie nueva,** de Costa Rica, la primera especie de *Carpomya* de las Américas. Se analizan las relaciones filogeneticas dentro de *Carpomya. Myiopardalis* Bezzi y *Goniglossum* Rondani son sinónimos subjectivos nuevos de *Carpomya.* Se transfieren *C. pardalina* (descrita originalmente en *Carpomya*) y *Carpomya wiedemanni,* n. comb., a *Carpomya* de *Myiopardalis* y *Goniglossum,* respectivamente, y se remueve *Spilographa caucasica* Bigot de este género. Se designa un lectotipo para *C. pardalina,* y se provee una clave a las especies de *Carpomya.*

Key Words: Fruit flies, Tephritidae, *Carpomya, Myiopardalis, Goniglossum*

The genus *Carpomya* Costa (1854) previously included four species known from the southern Palearctic, northeastern Afrotropical, and western Oriental Regions, although one of these species, *C. caucasica* (Bigot) does not seem to belong in this genus. The monotypic genera *Myiopardalis* Bezzi (1910) and *Goniglossum* Rondani (1856), here considered new subjective junior synonyms of *Carpomya,* included one southern Palearctic/western Oriental species and one Palearctic species, respectively. This paper reports the discovery of the first American species of *Carpomya,* increasing the number of species of this genus to six, and substantially extending its distribution.

METHODS

I follow the morphological terminology of McAlpine (1981), except as noted by Norrbom and Kim (1988). Terminology for the wing pattern follows Foote (1981, see Fig. 71). Taxonomically useful characters within *Carpomya* are listed in Table 1 and the distributions of their states are shown in Table 2, but only the nine characters with an asterisk were used in the phylogenetic analysis; the others are autapomorphies. The Hennig86 program was used for phylogenetic analysis, with the *Rhagoletis tabellaria* group as the outgroup for assigning character polarities. Transformation series and the polarity of some characters are fur-

Table 1. Characters taxonomically useful for species of *Carpomya.* Only characters with an * were used in phylogenetic analysis.

1. Head elongate, gena especially produced and angulate anteriorly, and proboscis long geniculate—0) no; 1) yes.
2. Facial carina—0) moderately to strongly produced dorsally, gradually becoming broader and less produced ventrally; 1) weakly produced, gradually becoming broader ventrally; 2) strongly produced dorsally, rather abruptly becoming very broad and weakly produced near midlength; 3) extremely produced and moderately broad throughout, carinate on both sides. States 1, 2, and 3 are here considered independently derived autapomorphies.

*3. Ocellar setae—0) well developed; 1) minute, length less than width of ocellar tubercle.

4. First flagellomere—0) with dorsoapical point; 1) rounded dorsoapically.

*5. Mesonotal color and microtrichia pattern—0) unicolorous except white areas, or if partially brown without microtrichia or with microtrichia unicolorous; 1) with pattern of dark brown or black marks (similar to Fig. 1), some without microtrichia, others with dense black microtrichia.

*6. Scutellar color pattern—0) brown basally, white apically; 1) with medial brown spot extended to apex or with smaller isolated medial brown spot and apical brown spot(s); 2) without medial brown spot, pale area m-shaped, with medial pale arm; 3) entirely yellow. The transformation series of this character is uncertain and it was coded unordered in the Hennig86 analysis. *Carpomya tica, pardalina* and *wiedemanni* were all coded 1, although there are some differences in their scutellar patterns: *C. tica* has a large medial brown spot and U-shaped yellow area which includes the apical setae (Fig. 1); *C. pardalina* has a smaller medial brown spot, isolated by a larger pale area from an apical brown spot or spots on which the apical setae are located; and *C. wiedemanni* is variable, either like *C. pardalina,* or with the medial brown spot large and including the apical setae (Freidberg & Kugler 1989: 191).

*7. Scutellum shape—0) relatively triangular in dorsal view, disc flat to slightly convex; 1) almost semicircular in dorsal view, disc slightly to moderately convex (a little less convex in *incompleta* than in *schineri* and *vesuviana*); 2) almost semicircular in dorsal view, disc very strongly convex.

*8. Katepisternum—0) unicolorous brown (*R. tabellaria* group) or yellow (*C. tica*); 1) yellow or orange, with dorsal margin white (contrast often weak in *C. incompleta* and *pardalina*); 2) with large brown or black area, dorsal margin white. State 0 appears to be plesiomorphic, although it should be noted that states 1 and 2 occur in *Zonosemata.*

*9. Cell r_1 with spur vein—0) with at most a dark spot or crease within the subapical band; 1) with a distinct spur vein originating from vein R_{2+3} in the subapical band.

10. Crossvein r-m—0) near midpoint between bm-cu and dm-cu, within or at apical margin of discal band; 1) at 0.73 distance from bm-cu to dm-cu, touching proximal margin of subapical band.
11. Subbasal and discal bands—0) not connected or connected posteriorly; 1) connected in cells r_1 and br.
12. Anterior apical wing band—0) present; 1) absent.

*13. Epandrium—0) mostly brown; 1) mostly yellow with small dorsomedial brown spot. In other mostly yellow Carpomyini the epandrium is mostly brown or all yellow or has paired dorsolateral spots, although in *Zonosemata* it varies from states 0 to 1, sometimes intraspecifically.

14. Aculeus tip—0) nonserrate; 1) serrate.

*15. Spermatheca number—0) 3; 1) 2. The number of spermathecae varies from 2–3 in the *R. tabellaria* group and other *Rhagoletis* and Carpomyini (Bush 1966, Norrbom 1994b), but 3 is the plesiomorphic state for Tephritidae, so I tentatively coded that number as plesiomorphic within *Carpomya* and assigned that state to the outgroup in the Hennig86 analysis.

16. Spermatheca shape—0) single chambered; 1) double chambered.

*17. Host plant—0) *Rosa* spp. (Rosaceae); 1) *Ziziphus* spp. (Rhamnaceae); 2) Cucurbitaceae (*C. paradalina* breeds in *Cucumis, Citrullus,* and *Ecballium* spp., and *C. wiedemanni* in *Bryonia* spp.). The transformation series is uncertain; states 1 and 2 are probably apomorphic, as *C. pardalina* and *C. wiedemanni* are the only two species of Carpomyini known to breed in Cucurbitaceae, and *C. incompleta* and *C. vesuviana* are the only Carpomyini known from Rhamnaceae (Freidberg & Kugler 1989, White & Elson-Harris 1992), but these states may be independently derived from state 0 or some other state (a wide range of host families are attacked by Carpomyini). The hosts of *C. tica* are unknown. Coded unordered in the Hennig86 analysis.

Table 2. Character state distributions among species of *Carpomya.*

	Characters																
Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
outgroup	0	0/1	0	0	0	0	0	0	0	0	0	0	0	0	0/1	0	?
tica	0	1	0	0	1	1	2	0	0	1	0	0	0	?	?	?	?
pardalina	0	2	0	0	1	1	0	1	1	0	0	0	1	0	0	1	2
wiedemanni	1	3	0	1	1	1	0	2	1	0	1	0	1	1	0	0	2
schineri	0	0	0	0	1	2	1	2	0	0	0	0	1	0	1	0	0
incompleta	0	0	1	0	0	3	1	1	0	0	0	1	1	0	1	0	1
vesuviana	0	0	1	0	1	2	1	1	0	0	0	0	1	0	1	0	1

ther discussed in Table 1. Note that characters 6 and 17 were treated as unordered.

TAXONOMY

KEY TO THE SPECIES OF *CARPOMYA*

1. Vein R_{2+3} with a distinct, anteriorly directed spur vein in the subapical band. Three spermathecae. Host plants Cucurbitaceae. 2

– Vein R_{2+3} without a spur vein, cell r_1 with at most a dark spot or crease within the subapical band. Two spermathecae (unknown for *C. tica*). Host plants not Cucurbitaceae (unknown for *C. tica*). 3

2. Head elongate, gena especially produced and angulate anteriorly. Proboscis long geniculate. Facial carina strongly produced throughout and only slightly wider ventrally than dorsally. Katepisternum with a large dark brown spot medially. Subbasal and discal bands connected in cells r_1 and br. Aculeus tip serrate. Europe, Israel. . . . . *wiedemanni* (Meigen)

– Head not elongate, gena rounded anteriorly. Proboscis short, capitate. Facial carina strongly produced dorsally, but ventral half very broad and weakly produced. Katepisternum yellow or orange, except for whitish dorsal margin. Subbasal and discal bands not connected. Aculeus tip nonserrate. Caucasus, Turkey, Cyprus and Egypt to western India. . . . . *pardalina* Bigot

3. Crossvein r-m near midpoint between bm-cu and dm-cu, within or at apical margin of discal band. Scutellum dark brown with m-shaped whitish area, including a medial pale mark, or entirely yellow. Old World. 4

– Crossvein r-m at about ¾ distance from bm-cu to dm-cu, touching proximal margin of subapical band (Fig. 2). Scutellum dark brown with U-shaped yellowish mark (Fig. 1), without medial pale mark. Host plants unknown. Costa Rica. *tica,* n. sp.

4. Scutum and scutellum with large dark brown or black spots or markings. Anterior apical band of wing present. Ocellar seta well developed or minute. 5

– Scutum and scutellum without brown or black spots or markings. Anterior apical band of wing absent. Ocellar seta minute, length less than width of ocellar tubercle. Host plants *Ziziphus* spp. Southern Europe, Middle East, Egypt, Sudan, Ethiopia. . . . . *incompleta* (Becker)

5. Ocellar seta well developed. Katepisternum with at least a large dark brown spot medially, usually mostly dark brown except whitish dorsal margin. Host plants *Rosa* spp. Central Europe to Kazakstan and Israel. . . . *schineri* (Loew)

– Ocellar seta minute, length less than width of ocellar tubercle. Katepisternum yellow or orange, except for whitish dorsal margin. Host plants *Ziziphus* spp. Italy, Bosnia, Caucasus, Central Asia, Pakistan, India, Thailand. . . . . *vesuviana* Costa

Carpomya pardalina Bigot

Carpomyia pardalina Bigot 1891: 51.

Myiopardalis pardalina: Bezzi 1910: 11; Freidberg and Kugler 1989: 194; White and Elson-Harris 1992: 349. See latter two publications for additional references.

Carpomyia (Myiopardalis) pardalina: Zaitzev 1919: 66; Rohdendorf 1939: 8; Kandybina 1965: 668 [larva].

Carpomyia (Myiopardalis) caucasica Zaitzev 1919: 64; Stackelberg 1928: 281 [synonymy]; Zaitzev 1947: 6 [synonymy].

Bigot described *C. pardalina* from "plusieurs" (several) specimens of both sexes from "Beloutchistan" (Baluchistan, an area extending from southeastern Iran to western

Pakistan). In the Bigot Collection, now at the University Museum, Oxford, there are three specimens (2 ♂ 1 ♀) on separate pins, one of each sex also with a larva pinned below the adult specimen. The pin of the female, here designated as lectotype, has a thin paper label of the style that Ackland and Taylor (1972, Fig. 6) found mainly on specimens with Bigot manuscript names. The lectotype's label has the following data in Bigot's writing: "Carpomyia pardalina [the second half of the specific name written over some other letters] ♀ \ n. sp. Inedit. \ qui[rest of word illegible] Octobre 1890. J. Bigot \ Beloutchistan \ attaque les melons." There is a fourth pin with a similar label except for a "♂" symbol instead of "♀." It has only some debris, perhaps the remains of a third syntype male. The lectotype is pinned through its abdomen and has slightly shriveled eyes, but otherwise is in good condition. All of these specimens fit Bigot's description and the traditional interpretation of this species.

Carpomyia caucasica Zaitzev (1919) was described from male and female specimens from "East Transcausia, Dzhevanshir, Areshsk territory, Elisavetn region and North Mugan." Elisavetn is probably the locality in Azerbaijan that has also been known as Gandzhe, Kirovabad, and Yelisavetpol (A. Konstantinov, personal communication). This name has long been considered a synonym of *C. pardalina* by Russian workers (Stackelberg 1928, Zaitzev 1947, Kandybina 1965), but has been little noticed by western authors. It was omitted from the Palearctic Diptera catalog (Foote 1984). I examined a pair of specimens of *C. pardalina* in the Zoological Institute, St. Petersburg with the following label data: "A3. o. 3. CT." [= Azerbaijan?] and handwritten localities that I cannot decipher; the male with the date "19/viii 1928", and the female with the date "3/viii 1927." The female also has a determination label with "*Myiopardalis caucasica* m., Zaitzev det." These specimens cannot be types because their collection dates are subsequent to the date of description, but their identity helps to confirm the synonymy of this name.

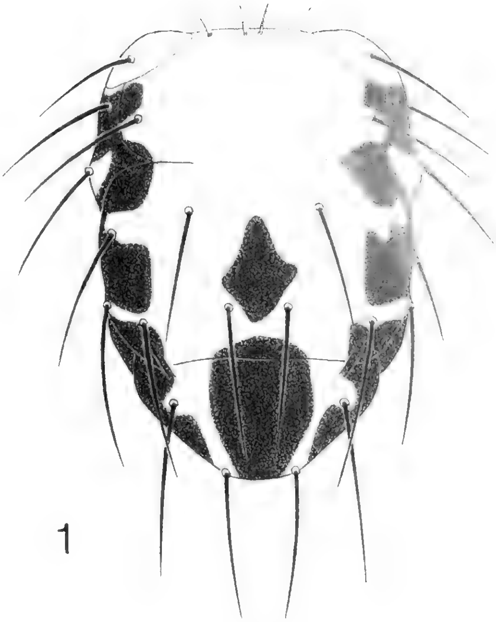


Fig. 1. *Carpomya tica*, thorax, dorsal view.

As explained in the Relationships section, I follow Zaitzev (1919, 1947), Rohdendorf (1939) and Kandybina (1965) in including *pardalina* in *Carpomya,* rather than in the monotypic genus *Myiopardalis,* as it has been treated by the majority of authors.

Carpomya tica Norrbom, new species

(Figs. 1–4)

Holotype.—♂ (at USNM, for eventual deposit in Instituto Nacional de Biodiversidad, Heredia, Costa Rica), COSTA RICA: San José: Zurquí de Moravia, 10°03′N 84°01′W, 1600 m, Malaise trap, V.1992, P. Hanson.

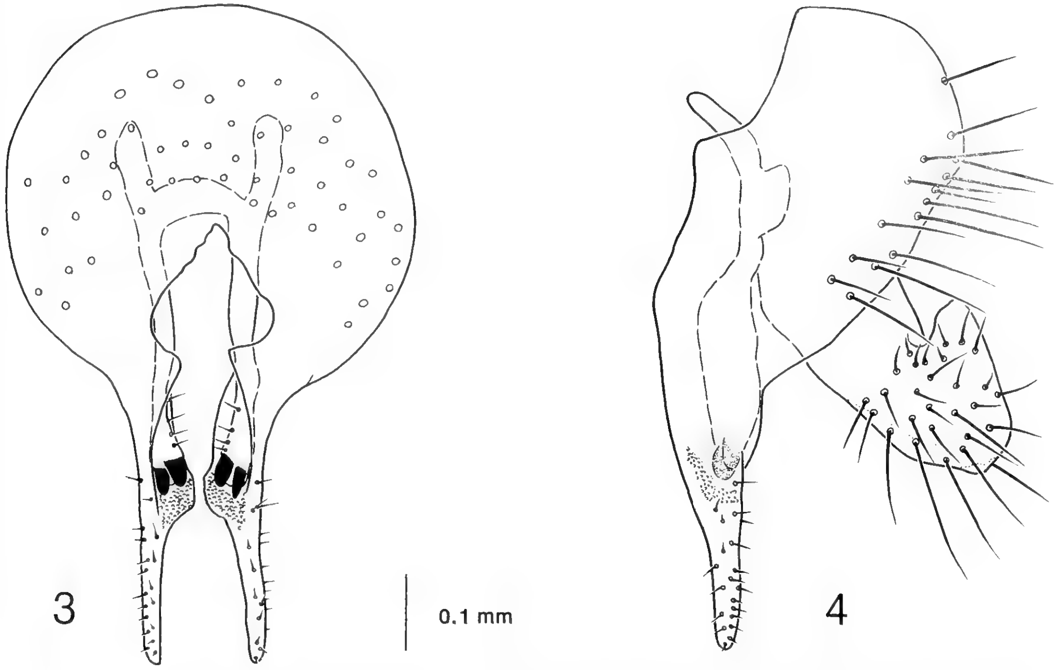
Diagnosis.—*Carpomya tica* differs from all other species of *Carpomya* and most other Carpomyina in the distal location of crossvein r-m (Fig. 2), which is at the apical ¾ of cell dm versus near the middle of that cell in other Carpomyina except *Cryptodacus* spp. and *Haywardina cuculi* (Hendel), which differ from *Carpomya* in having

2

Fig. 2. *Carpomya tica,* right wing.

a white medial scutal stripe or spot. *C. tica* also differs from other species of Carpomyina, including most of the other species of *Carpomya,* by the strongly swollen shape of its scutellum. Only *C. schineri* and *C. vesuviana* approach *C. tica* in scutellum shape, but neither has this structure as stout as in *C. tica,* and they further differ in the shape of the pale area of their scutellar color patterns, which is somewhat m-shaped, with a medial pale mark (see Freidberg and Kugler 1989, Fig. 188), rather than U-shaped as in *C. tica* (Fig. 1; the yellow areas are continuous on the extreme apex of the scutellum, visible in posterior view). In the key to Neotropical genera of Tephritidae in Foote (1980), *C. tica* will key to *Cecidochares,* which is not closely related (it belongs to the subfamily Tephritinae). Species of the latter genus differ as follows: body mostly dark brown, including all of the scutum and scutellum; at least some scutal setulae swollen; and outer and inner surstyli short.

Description.—Setae black. Body predominantly yellow. *Head:* Yellow. 3 frontal, 2 orbital setae, all large. Ocellar seta large (length about equal to width of frons). Facial carina weak. First flagellomere about 2 times as long as wide (lateral view), with small dorsoapical point. Proboscis short, capitate. *Thorax:* Mostly yellow. Postpronotal lobe, dorsal margin of anepisternum, and posterior third of notopleuron white. Mesonotum (Fig. 1) with following dark brown markings: medial spot from level of dorsocentral seta to level of acrostichal seta, extended laterally slightly beyond acrostichal seta; spot on anterior two-thirds of notopleuron, extended mesally on scutum to level of presutural supra-alar seta but not including it; broad spot along transverse suture; spot from wing base to slightly mesal to level of intra-alar seta and from postsutural supra-alar seta almost to post-alar and intra-alar setae; spot posterior and lateral to intra-alar seta; and scutellum, except for narrow, U-shaped yellow mark that includes apical and basal setae. Pleuron without dark brown markings. Subscutellum entirely dark brown. Mediotergite yellow laterally, broadly dark brown medially, more broadly so dorsally. Scutellum strongly swollen. Chaetotaxy as in *Rhagoletis* and *Carpomya.* Dorsocentral seta slightly anterior to level of postsutural supra-alar seta. Scapular setae white. Mesonotal setulae slender; those on scutum yellow or black, occurring in patches. Scutellum with yellow setulae, present only on yellow areas. Mesonotum mostly moderately densely pale microtrichose, except for dark brown part of notopleuron, dark brown spot along transverse suture, lateral half of brown spot



Figs. 3–4. *Carpomya tica,* male genitalia. 3, Epandrium and surstyli, posterior view (cerci not shown). 4, Epandrium, surstyli and cercus, lateral view.

between postsutural supra-alar and intra-alar setae, and spot posterior and lateral to intra-alar seta, which are densely black microtrichose, and the following nonmicrotrichose areas: dark brown part of scutum mesal to notopleural dark area; middle of medial scutal brown spot; mesal half of brown spot between postsutural supra-alar and intra-alar setae; and scutellum except yellow areas and base and apex of lateral brown area. Subscutellum and upper half of brown area of mediotergite densely blackish microtrichose; yellow parts of mediotergite moderately pale microtrichose; ventral part of brown area bare. *Legs:* Yellow, except hind tibia with basal posterior and subapical anterior and posterior brown spots. *Wing* (Fig. 2): With subbasal, discal, preapical and anterior apical bands. Accessory costal band and posterior apical bands absent. Discal and subapical bands parallel, perpendicular to long axis of wing; each broad, but not connected. Anterior apical band only narrowly connected to subapical band in cell r_1, and separated from costa by hyaline marginal spots in cells r_1 and cell r_{2+3}. Cell r_1 without spur vein from vein R_{2+3} in subapical band. Crossvein r-m at 0.73 distance from bm-cu to dm-cu (just touching proximal margin of subapical band). Cell bcu with apical lobe 0.5 times as long as maximal width of cell. *Abdomen:* Mostly yellow, each tergite (through tergite 5) with unpaired medial and paired sublateral brown spots, small on syntergite 1+2. *Male terminalia* (Figs. 3–4): Epandrium brown, surstyli yellow. Outer surstylus slender, with distinct mesal lobe; part apical to mesal lobe with relatively few small setulae.

Spilographa caucasica Bigot

Hendel (1927) placed this species in *Carpomya,* but probably based on confusion with *Carpomyia caucasica* Zaitzev (= *C. pardalina*). Without examination of the holotype it is difficult to recognize *S. caucasica.* Bigot's description is vague and there are no illustrations. But it is very doubtful that *S. caucasica* belongs in *Carpomya,* as no species of that genus has a longitudinal band in addition to four transverse bands on the wing. Bigot's statement "quatre bandes roussatres, peu distinctes, sises a la partie postérieure du thorax" (4 reddish bands, not very distinct, situated at the posterior part of the thorax), also seems questionable for a species of *Carpomya,* which except for *C. incompleta* (which has only 3 wing bands and therefore cannot be *S. caucasica*), have distinct dark brown spots or larger marks on the mesonotum. I cannot recognize *S. caucasica,* and treat it here as an unplaced species of Trypetinae.

Bigot (1880: 154, bottom of page) stated clearly that the species he described in this paper were in his collection, but Adrian Pont (personal communication) was unable to locate the single female (therefore holotype) of *S. caucasica* in the Bigot Collection at the University Museum, Oxford. He remarked that it is possibly there under "some other name that Bigot changed to *caucasica* with publication. He was prone to doing this, and it causes endless confusion."

RELATIONSHIPS AND CLASSIFICATION

The Carpomyina was proposed as a subtribe of Trypetini by Norrbom (1989), but is currently considered a subtribe of Carpomyini within the Trypetinae (Korneyev 1996). The desclerotized area at the apex of female syntergosternite 7 and the presence of stomal guards, usually distinctly sclerotized, in the larva are probable synapomorphies for the subtribe (Norrbom 1989, Carroll 1992). The shape of the male surstyli (inner and outer surstyli elongate, the latter with a long, apically directed posterior lobe and a short, mesally directed anterior lobe) is probably another synapomorphy of the Carpomyina or possibly for the Carpomyini (Korneyev 1996). Some reversal (reduction of the posterior lobe of the outer surstylus in a few taxa) must have occurred if this character was in the groundplan of the Carpomyina, but other character state distributions support that hypothesis (Norrbom 1989, 1994b).

Carpomya, as recognized here, includes six species: *C. incompleta* (Becker), *C. pardalina* Bigot, *C. schineri* (Loew), *C. vesuviana* Costa, *C. wiedemanni* (Meigen), **NEW COMBINATION** and *C. tica,* n. sp. *Carpomya tica* belongs in the Carpomyina, or at least to the Carpomyini, based on the shape of its male genitalia; its surstyli have the typical carpomyine shape (Figs. 3–4). With most of the other species of *Carpomya, C. tica* shares a distinctive, apomorphic color pattern of the cuticle and microtrichia of the thorax, which is mostly yellow with dark brown to black marks on the scutum, scutellum, and subscutellum (Fig. 1; also see Freidberg and Kugler 1989, Figs. 188, 202, 209). The microtrichia are pale or gray, except on some of the dark brown areas, which are bare or have dense, blackish microtrichia. Except for the subscutellar marks, this pattern has been lost in *C. incompleta,* which shares several synapomorphies with *C. schineri* and *vesuviana* (see Fig. 5), indicating that it does belong in *Carpomya* (J. Jenkins, personal communication, has discovered a male genitalic synapomorphy that further supports this clade). This color pattern is unique within the Carpomyina; in other genera, the thorax is dark brown or black (except, in many species, for the whitish postpronotal lobe, dorsal anepisternal stripe, apical part of scutellum, and sometimes a medial scutal spot or stripe) or predominantly yellow to orange, or if partly or mostly dark brown (e.g., *Zonosemata* or *Rhagoletis suavis* species group), the pattern is much different than in *Carpomya.* Some species of Ceratitidina in the Dacini do have thoracic color patterns similar to *Carpomya,* thus convergent evolution of such a pattern in *C. tica* and the Old World species of *Carpomya* is possible, but I have discovered no apomorphies shared by *C. tica* and any other species of Carpomyina (or other Trypetinae) that would contradict the hypothesis that *Carpomya,* as de-

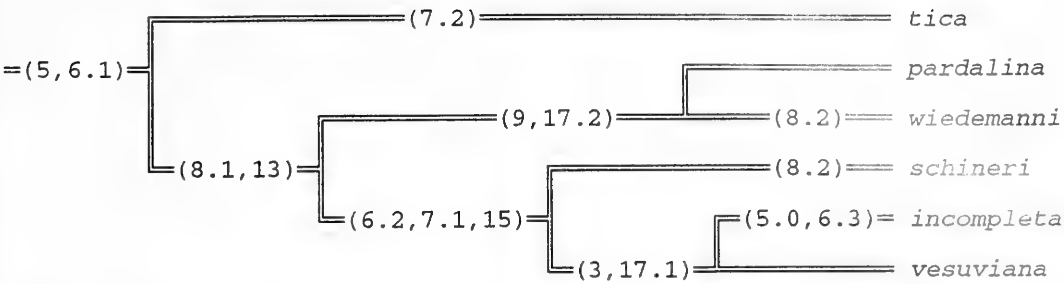


Fig. 5. Hypothesized phylogenetic relationships among species of *Carpomya*. Character numbers refer to Table 1.

limited here, is monophyletic. Other character state distributions indicate that the distal location of r-m in *C. tica* and *Cryptodacus* and *Haywardina cuculi* is the result of convergence (see Norrbom 1994b).

Certain characters of the wing pattern may be additional synapomorphies of *Carpomya,* although some species now placed in *Rhagoletis* (particularly the *tabellaria* species group) have similar wing patterns, so some or all of these characters could be plesiomorphic or synapomorphies at a higher level within the Carpomyina. Better understanding of the polarity and evolution of wing patterns within the Carpomyina is necessary to determine the phylogenetic significance of these characters, but at least the strong similarity of the wing pattern of *C. tica* with those of the other species of *Carpomya* does not contradict its classification in this genus. The similar elements of the wing pattern include: absence of the accessory costal band; absence of the posterior apical band; the broad width of all of the bands (reduced in *C. incompleta*) and their yellow to brown color; discal and subapical bands transverse and parallel; and the at least partial separation of the anterior apical band from the wing margin (Fig. 2; and Freidberg and Kugler 1989, Pl. VIII, Figs. 4, 8, 10).

The relationship of *Carpomya* to other genera of Carpomyina has not been resolved. Its closest relatives may be within the possibly paraphyletic genus *Rhagoletis* (Bush 1966: 451), and I tentatively used the *R. tabellaria* group, which has similar wing patterns, as the outgroup for analysis of character polarity.

The Hennig86 analysis of relationships within *Carpomya* (based on the nine characters with an asterisk in Table 1) resulted in the single tree shown in Figure 5 (length 17 steps, consistency index 82, retention index 75). *Carpomya incompleta, schineri* and *vesuviana* form one monophyletic subgroup, and *C. pardalina* and *wiedemanni* form another. These groups together appear to be the sister group of *C. tica.* Despite having several distinctive autapomorphies (greatly elongated mouthparts and head, facial carina shape, apically rounded first flagellomere, and serrate aculeus tip; see Freidberg and Kugler 1989, Figs. 201, 204), *C. wiedemanni,* the type species of *Goniglossum,* appears to be most closely related to *C. pardalina,* which is the type species of *Myiopardalis.* The synonymy of *Goniglossum* and *Myiopardalis* with *Carpomya* (type species *C. vesuviana*) is a subjective decision of ranking, but their continued recognition as monotypic genera (or the placement of both species in *Goniglossum*) would require the proposal of yet another monotypic genus for *C. tica.* Considering the diversity of species now classified in *Rhagoletis,* I find the latter option undesirable. Already, Zaitzev (1919, 1947), Rohdendorf (1939) and Kandybina (1965, 1977) considered *Myiopardalis* a subgenus of *Carpomya.* The latter author found little difference among the larvae of the species here included in *Carpomya,* except that the oral ridges are reportedly nonserrate in *C. wiedemanni.* This character (not verified by personal examination by Kandybina in *C. wiedemanni*) varies in other genera (e.g., *Anastrepha,* see White and Elson-Harris 1992), and Kandybina otherwise considered *C. wiedemanni* larvae most similar to those of *C. pardalina* and *Rhagoletis flavigenualis* Hering of the *tabellaria* species group.

BIOGEOGRAPHY

The Carpomyina are distributed predominantly in the Holarctic Region and in higher altitude or temperate areas of the Neotropical Region. Although the Tephritidae and most of its major clades probably originated in the Old World, the discovery of *C. tica* in the Neotropics lends further support to the hypothesis that the Carpomyina originated and diversified in the Americas, with subsequent reinvasion of the Old World (Norrbom 1994a). Although a thorough phylogenetic analysis of the Carpomyina is needed to test this hypothesis of origin, it is supported by diversity data for the group. Except for the little known monotypic South African genus *Scleropithus* Munro, which appears to belong in the Carpomyina (A. Freidberg, personal communication), all of the genera of Carpomyina are now known from the Americas. This includes all of the species groups of the large, probably paraphyletic genus *Rhagoletis,* except for the *cerasi* group. Furthermore, all of these taxa except *Carpomya* and the *alternata* and *tabellaria* species groups of *Rhagoletis* are more diverse in the New World (Berlocher and Bush 1982, Norrbom 1994b).

ACKNOWLEDGMENTS

I am grateful to Paul Hanson for allowing me to study the interesting Costa Rican tephritids taken in his Malaise traps, including the unique holotype of *C. tica.* Adrian Pont arranged the loan of the types of *C. pardalina* and searched for the holotype of *Spilographa caucasica,* and V. F. Zaitzev arranged the loan of specimens from the Zoological Institute, St. Petersburg. Alexander Konstantinov and Raymond Gagné translated pertinent sections of Russian and French publications. John Jenkins and Amnon Freidberg kindly shared some unpublished data (a genitalic synapomorphy confirming the monophyly of the *vesuviana* group, and notes on the classification of *Scleropithus,* respectively), as well as their thoughts regarding the relationships and classification of the Carpomyina. They, V. Hernández-Ortiz, G. J. Steck, and F. C. Thompson reviewed earlier drafts of the manuscript.

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REVIEW OF THE BLASTOBASINAE (LEPIDOPTERA: GELECHIOIDEA: COLEOPHORIDAE) OF THE GALÁPAGOS ISLANDS

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Abstract.—***Calosima darwini,* new species,** is described from the Galápagos Islands, Ecuador, and is the first member of the genus known beyond North America. *Auximobasis normalis* Meyrick, 1918 is a senior synonym of *Blastobasis crotospila* Meyrick, 1926, and is redescribed and transferred to *Blastobasis* Zeller, 1855. A key and illustrations of adults, including male and female genitalia, are provided for the two species of Blastobasinae known from the Galápagos Islands.

Key Words: South America, Ecuador, Galápagos, Lepidoptera, Gelechioidea, Coleophoridae, Blastobasinae, *Calosima, Blastobasis*

The Lepidoptera of the Galápagos Islands are known incompletely. Although a number of collections have been made and reported, they have been restricted to the larger moths and the butterflies (Beebe 1923, Butler 1877, Schaus 1923, Hayes 1975). Consequently, the microlepidoptera remain known only partially. Eleven species were recorded by Meyrick (1926), and four were added by Linsley and Usinger (1966) and Linsley (1977). Recent collections by Robert Silberglied in 1969 and more recently by Bernard Landry in 1989 and 1992 have resulted in considerably more specimens of microlepidoptera than have been available previously. For example, Landry amassed more than 3,000 specimens of microlepidoptera in 5 months of collecting on the Galápagos Islands. Studies of this material have yielded publications on Pterophoridae (Landry and Gielis 1992, Landry 1993), Choreutidae (Heppner and Landry 1994a), Heliodinidae (Heppner and Landry 1994b), and the present paper on Coleophoridae (Blastobasinae).

The Blastobasinae are probably one of the most commonly collected groups of Gelechioidea in the Americas. Yet this subfamily may be one of the least known to science. Generally, species are drab with few, if any, diagnostic wing color patterns, making identifications difficult unless the genitalia are examined.

Since Meyrick (1894) the Blastobasinae have been considered to be a monophyletic group. Recent studies (Adamski and Brown 1989, Hodges, in press) have corroborated this notion and have rigorously established relationships of the Blastobasinae within Gelechioidea. In this work the Blastobasidae (*sensu* Adamski and Brown, 1989) are treated as a subfamily within the Coleophoridae.

MATERIALS AND METHODS

Collecting methods and information on the islands visited are found in Landry and Gielis (1992) and Landry (1993). Specimens were prepared (pinned and mounted) in the field as demonstrated by Landry and Landry (1994).

The Methuen Handbook of Colour (Kornerup and Wanscher, 1978) is used as a color standard for the description of the adult vestiture. More than 150 specimens of Blastobasinae were examined, including type specimens. Genitalia were dissected as described following Clarke (1941), except mercurochrome and chlorazol black were used as stains. Pinned specimens and genital preparations were examined with dissecting and compound microscopes. Wing measurements were made using a calibrated ocular micrometer.

RESULTS

KEY TO THE BLASTOBASINAE (COLEOPHORIDAE) OF THE GALÁPAGOS ISLANDS

1. Male 2
– Female 3
2. Forewing pattern with or without median fascia, with a single midcell dot and two dots near distal end of cell (Figs. 2–7); hindwing cubitals of equal length (Fig. 11); first flagellomere dilated forming a notch; apex of uncus rounded gnathos with two medial dentitions, proximal flange without dilation (Fig. 12); aedeagus short, slightly angled (Fig. 13) . . . . *B. normalis* Meyrick
– Forewing pattern without median fascia and with a single midcell dash and one dot on distal end of cell near cubitus (Fig. 1); hindwing cubitals of unequal length (Fig. 10); first flagellomere not dilated; apex of uncus obtuse, gnathos without dentitions, proximal flange with an angular dilation (Fig. 8); aedeagus long, sickle-shaped (Fig. 9) . . . . *C. darwini,* n. sp.
3. Forewing pattern with or without median fascia, with a single midcell dot and two dots near distal end of cell (Figs. 2–7); hindwing cubitals of equal length (Fig. 11); ostium near seventh sternum, anterior margin of eighth sternum entire, ductus seminalis near ostium, ductus bursae long, signum hornlike (Fig. 15) . . . . *B. normalis* Meyrick
– Forewing pattern without median fascia, with a single midcell dash and one dot on distal end of cell near cubitus (Fig. 1); hindwing cubitals of unequal length (Fig. 10); ostium near eighth sternum, anterior margin of eighth sternum notched, ductus seminalis not close to ostium, ductus bursae short, signum platelike (Fig. 14) . . . . *C. darwini,* n. sp.

Calosima darwini **Adamski and Landry, new species**
(Figs. 1, 8–10, 14)

Diagnosis.—Forewing with a midcell dash; male genitalia with apex of uncus obtuse, ventrally keeled; dorsal part of proximal flange dilated; juxta divided; aedeagus long and sickle-shaped; female genitalia with widened base of ductus seminalis, and signum keeled longitudinally.

Head: Vertex and frontoclypeus with white scales intermixed with tricolored scales, basal ⅔ white, pale grayish brown distally, with a white apex; some specimens have mostly tricolored scales on vertex intermixed with white scales; outer surface of labial palpus pale grayish brown intermixed with white scales, mostly white to near distal margin of segments, inner surface white intermixed with few pale grayish-brown scales; antennal scape and pedicel white, flagellum pale brown; proboscis white intermixed with pale grayish-brown scales.

Thorax: Tegula and mesoscutum white intermixed with tricolored scales, or mostly pale grayish-brown scales intermixed with few white scales. Legs with outer surface brown or pale-brown scales intermixed with white scales. Scales white to near distal margin of segments; inner surface of legs white. Forewing (Fig. 1): length 4.0–6.9 mm (n = 24), mostly white intermixed with tricolored scales, or both types of scales intermixed about equally; basal ½ of radius and cubitus demarcated by brown scales, a brown dash about midcell, and a brown dot within distal part of cell near cubitus, (these markings may be faint or absent in some rubbed specimens); submarginal scales mostly pale brown or brown, marginal scales mostly white; undersurface uniform pale brown. Venation (Fig. 10), with M_3 arched and cubitals originating from common area. Hindwing with both surfaces uniform pale brownish gray; venation (Fig. 10)

Fig. 1. Holotype of *Calosima darwini.*

with CuA_1 branched from M_3 near base, M_2 broadly arched toward M_1.

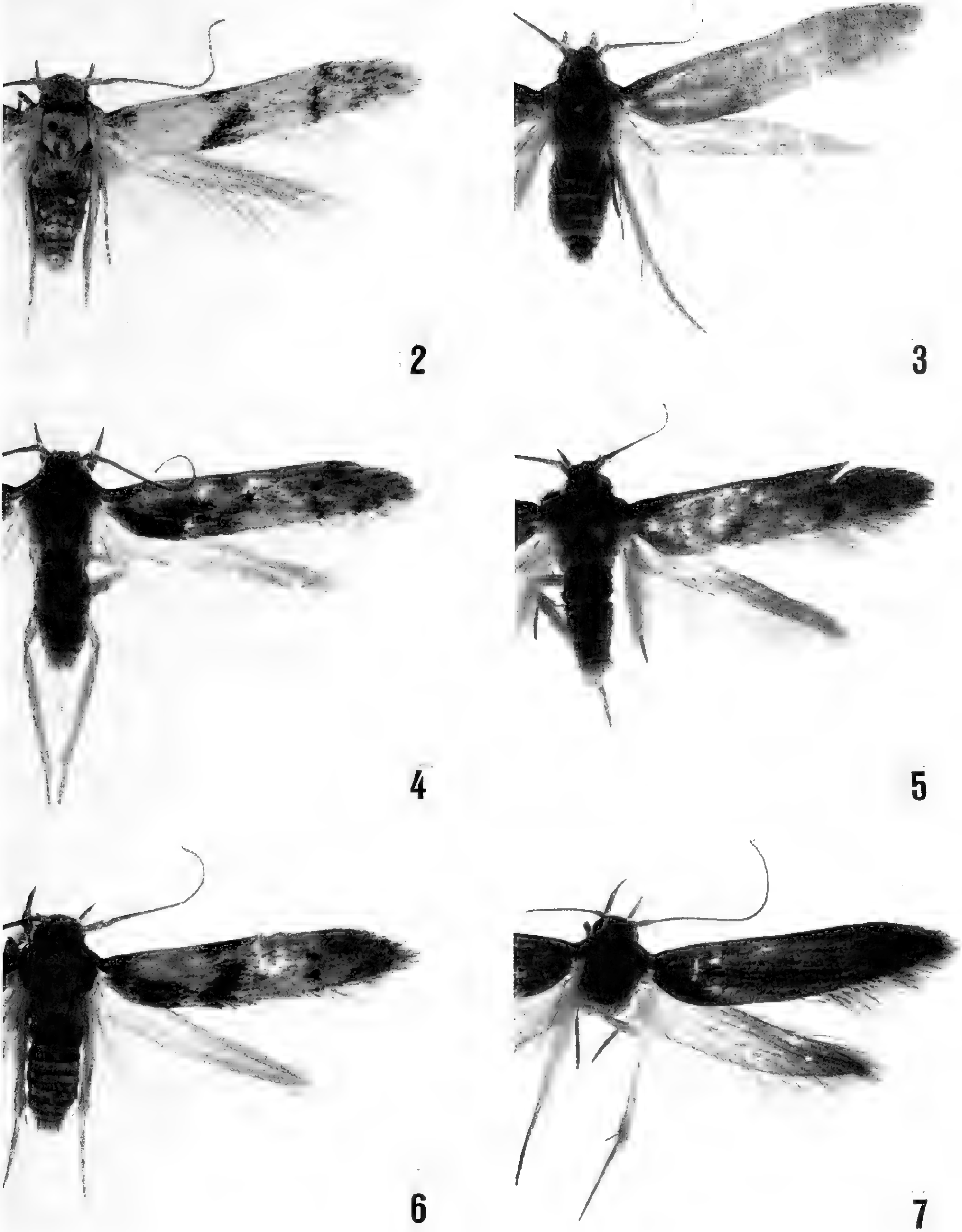
Abdomen: White.

Male Genitalia (Figs. 8–9): Uncus ventrally keeled, apex obtuse, slightly narrowed basally, with two pairs of ventral setae; base of uncus with two small depressions; dorsal margin of gnathos slightly rounded; distal ¾ of digitate upper division of valva setose, lower division basally widened, acuminate; dorsal part of proximal flange dilated, dilation angular and setose; juxta divided forming two semicircular bands; vinculum narrow, medially acuminate; aedeagus long and slender, sickle-shaped, slightly bulbous basally; anellus with microsetae.

Female Genitalia (Fig. 14): Ovipositor telescopic, in three membranous subdivisions; ostium near anteriorly notched eighth sternum; antrum membranous and undifferentiated from ductus bursae; ductus seminalis widened basally, narrowed distally; corpus bursae with large platelike signum, longitudinally keeled and narrowed posteriorly.

Holotype.—♂, "ECUADOR, GALAPAGOS, San Cristobal, 2 km, SW P[uer]to Baquarizo [sic], 11/II/1989, M[ercury] V[apor] L[ight], B[ernard] Landry". Deposited in the Canadian National Collection [CNC]. Specimen not dissected.

Paratypes.—Floreana: 3 ♂, "ECU[ADOR], GALAPAGOS, Floreana Punta Cormoran, 21/IV/1992, MVL, leg. B. Landry", specimen not dissected; 2 ♀ same data as above except; "23/IV/1992", specimens not dissected. Rabida: 1 ♂, 1 ♀, "ECU[ADOR], GALAPAGOS, Rabida, Tourist trail MVL, 3/IV/1992, leg. B. Landry", specimens not dissected. San Cristobal: 2 ♀, "ECUADOR, GALAPAGOS, San Cristóbal, 2km SW P[uer] to Baquarizo [sic], 11/II/1989, MVL, B. Landry", specimens not dissected; 1 ♀ with same data as above except; "17/II/1989", "♀ genitalia slide by D. Adamski 3312" [green label], "♀ wing slide by D. Adamski 3350" [green label].



Figs. 2–7. Adults of *Blastobasis normalis*, variation.

Santa Cruz: 3 ♂; "ECUADOR, GALAPAGOS, Santa Cruz, Arid Zone, 17/I/1989, MVL, B. Landry", "♂ genitalia slide by D. Adamski 3285" [green label], "♂ genitalia slide by D. Adamski 3293" [green label]; 1 ♂ paratype not dissected; 6 ♀; 1 ♀ with same data as above, [specimen not dissected]; 2 ♀ with same data as above except:

"16/I/1989", "♀ genitalia slide by D. Adamski 3287" [green label]; "29/I/1989" [specimen not dissected]; 3 ♀; "ECU[ADOR], GALAPAGOS, Santa Cruz, E.C.C.D., 4/III/1992, MVL, leg. B. Landry" "♀ genitalia slide by D. Adamski 3286" [green label]; 1 ♀ with same data as above except; "6/III/1992, UVL", specimen not dissected; 1 ♀ with same data as above except; "Conway, 14/IV/1992", "♀ genitalia slide by D. Adamski 3288" [green label]. 5 ♀ specimens collected by R. Silberglied with the following data: "GALAPAGOS I[SLANDS], SANTA CRUZ; Academy Bay, C[harles] Darwin Res[earch] Sta[tion], Aug[ust] [19]70, Alt[itude] (+, −) 5m, R. Silberglied", "at 15w UVL blacklight", "♀ genitalia slide by D. Adamski 615" [green label]; 3 ♀ with same data as above except; "♀ genitalia slide by D. Adamski 616" [green label], "♀ wing slide by D. Adamski 843" [green label]; "♀ genitalia slide by D. Adamski 617" [green label], "♀ wing slide by D. Adamski 717" [green label]; one ♀ specimen with same data as above except; "25 FEB[ruary] [19]70", "♀ genitalia slide by D. Adamski 618" [green label]. Santiago: 1 ♀, "ECU[ADOR], GALAPAGOS, Santiago, Bahia Espumilla, 4/IV/1992, MVL, leg. B. Landry", "♀ genitalia slide by D. Adamski 3318" [green label]. 1 ♂ and 1 ♀ paratype are deposited in the National Museum of Natural History, Smithsonian Institution, [USNM] and The Natural History Museum, London [BMNH]. The five paratypes collected by R. Silberglied are deposited in the Museum of Comparative Zoology, [MCZ] Harvard University. The remaining paratypes are deposited in the Canadian National Collection [CNC], Ottawa and the personal collection of B. Landry.

Remarks.—This is the first record of *Calosima* beyond North America. *Calosima darwini* and *C. lepidophaga* (Clarke) are the only known Holcocerini that share a divided juxta.

Etymology.—*Calosima darwini* is named after Charles Darwin, whose observations of the flora and fauna of the Galápagos Islands are fundamental to evolutionary thought.

Blastobasis normalis Meyrick, 1918, **new combination**
(Figs. 2–7, 11–13, 15)

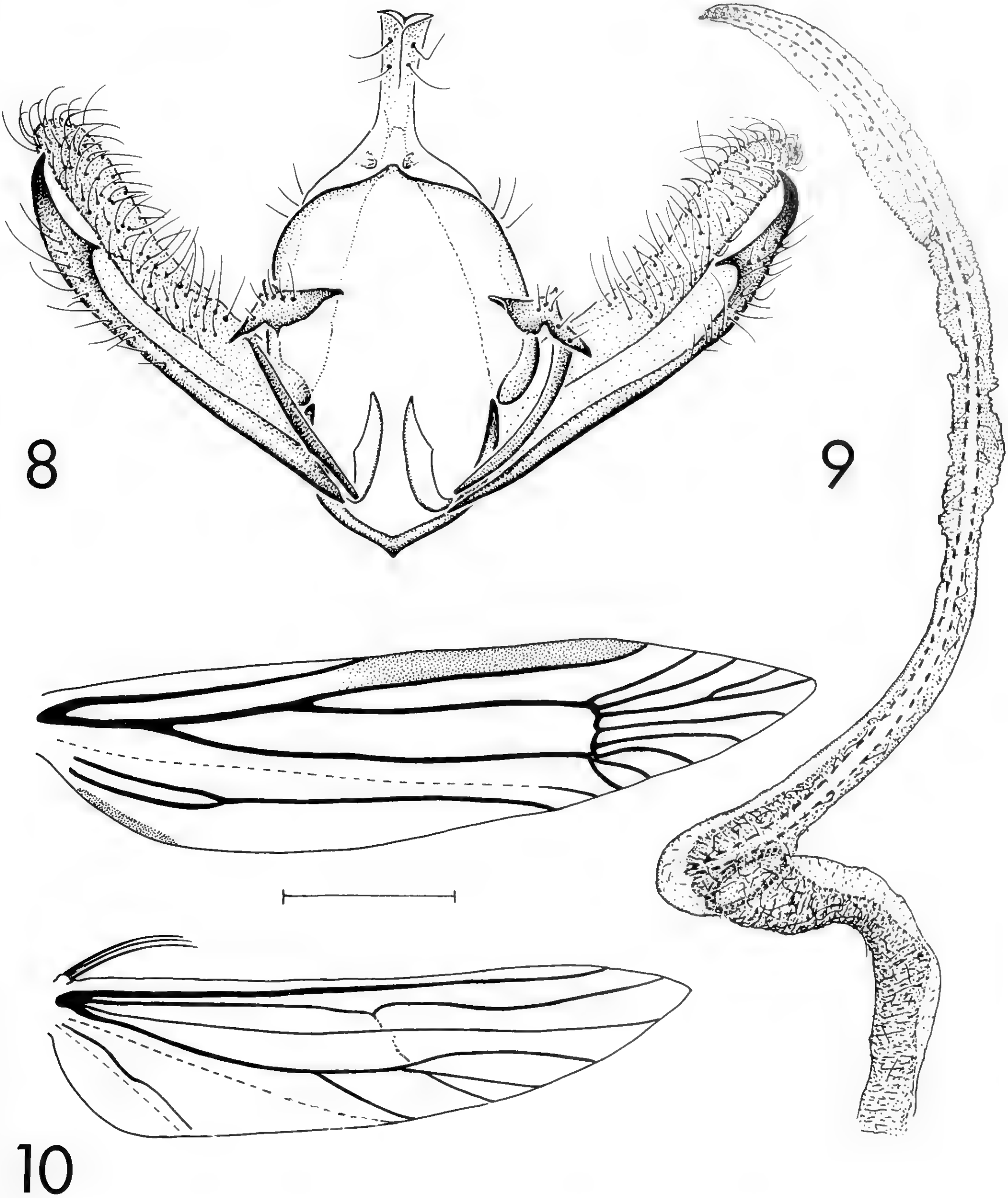
Auximobasis normalis Meyrick, 1918:2: 160.—Clarke, 1963:4:481.—Heppner, 1984:41.

Blastobasis crotospila Meyrick, 1926:74: 278.—Linsley and Usinger, 1966:33(7): 164.—Parkin et al., 1972:48(2):105.—Heppner, 1984:41. **New synonymy.**

Diagnosis.—Male genitalia with lower division of valva with long marginal setae; female genitalia with moderately dense microtrichia on membrane near ostium.

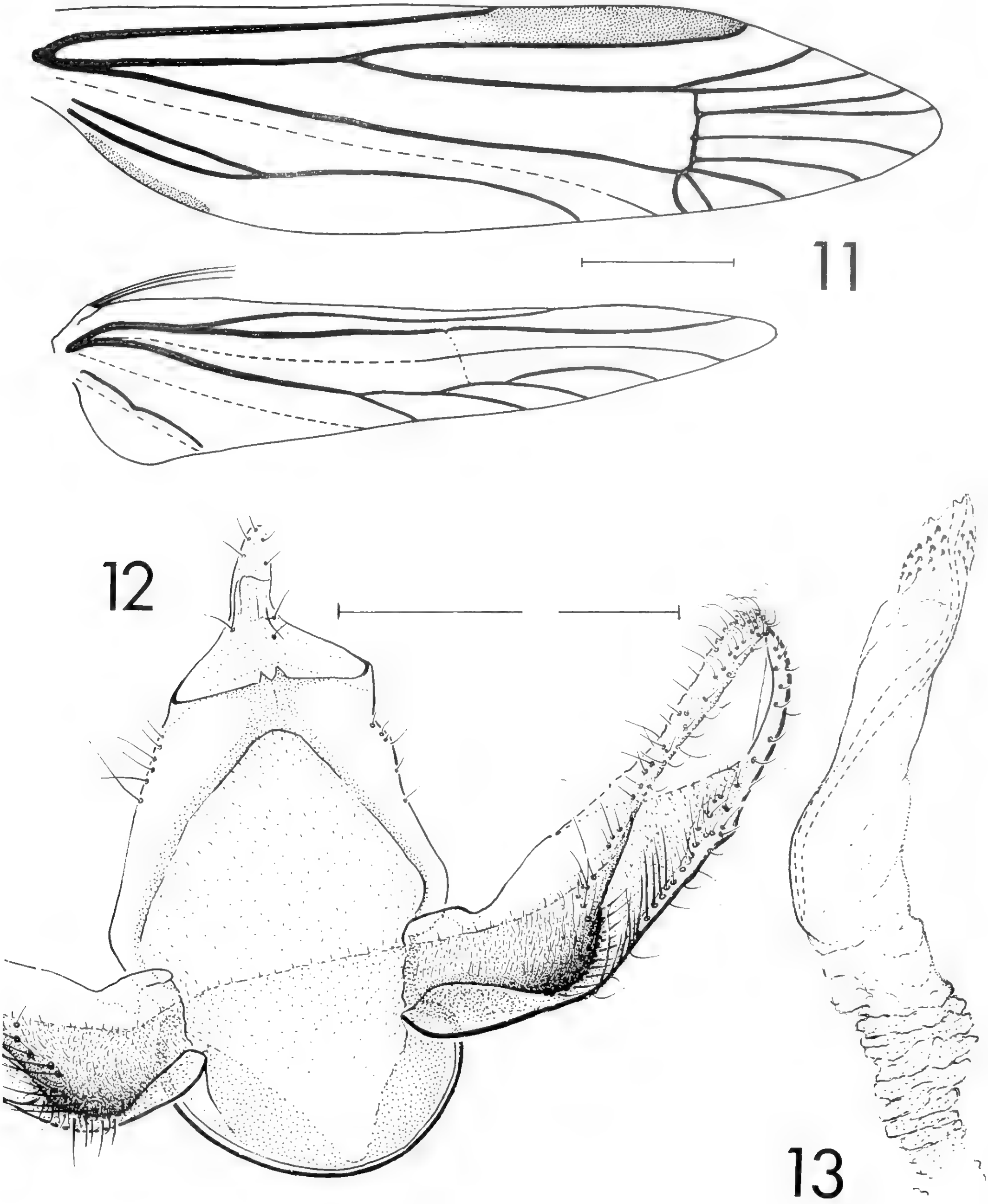
Head: Frontoclypeus and vertex variable; from grayish-brown scales tipped with white, to nearly white; darker specimens with scales in area between dorsal and ventral margins of antennal sockets with greater area of white or pale grayish brown on distal end, forming a transverse color band across frontoclypeus; outer surface of labial palpus brown or grayish brown intermixed with pale grayish-brown scales tipped with white, and few white and brown scales, each segment white to near distal margin; inner surface white or mostly white intermixed with pale-brown scales; antennal scape and pedicel patterned as above, male first flagellomere dilated, forming a notch, flagellum grayish brown; proboscis pale grayish brown intermixed with white.

Thorax: Tegula, brown or grayish brown, grayish brown basally, pale grayish brown, or white distally; mesoscutum patterned as tegula except, scales tipped with pale grayish brown or white form a broad transverse color band. Legs: outer surface with scales grayish brown or brown tipped with white, white near midtibia and distal margin of tarsomeres; inner surface mostly white intermixed with pale grayish-brown scales. Forewing (Figs. 2–7): length 4.2–6.4 mm (n = 129), highly variable; grayish brown,



Figs. 8–10. *Calosima darwini.* 8, Genital capsule. 9, Aedeagus. 10, Wing venation. Figs. 8, 9, Line Scale = 0.5 mm; Fig. 10, Line scale = 1.0 mm.

pale grayish brown or brown, most scales tipped with white; median fascia present or absent, complete or incomplete; one dot near midcell and two dots near distal margin of cell; some specimens with a brown basal streak on posterior margin (Figs. 4, 6–7); marginal dots demarcating radial, medial, and cubital veins; female specimens usually darker than males; undersurface brown, pale brown basally; venation (Fig. 11) with M_3 and CuA_1 not strongly arched. Hindwing with both surfaces pale grayish



Figs. 11–13. *Blastobasis normalis*. 11, Wing venation. 12, Genital capsule. 13, Male aedeagus. Fig. 11, Line scale = 1.0 mm; Figs. 12, 13; Line Scale = 0.5 mm.

brown; venation (Fig. 11) with cubitus 4-branched with M2, M3 stalked near midlength of preceding vein.

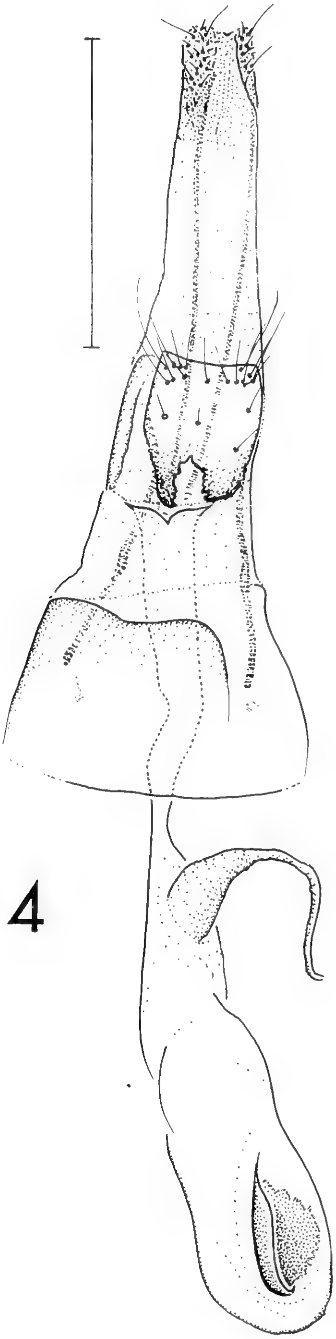
Abdomen: White.

Male genitalia (Figs. 12–13): Uncus parallel-sided with a rounded apex, sparsely setose; gnathos with a pair of small dentitions; tergal setae present; digitate upper division of valva slightly narrowed medially, broad at base, ventral margin setose; outer margin of proximal flange setose; diaphragma densely microtrichiate to margins of proximal flange; lower division of valva with long marginal setae; juxta bandlike; vinculum wide; aedeagus slightly angled, with several moderately stout anellar setae.

Female genitalia (Fig. 15): Ovipositor with four membranous subdivisions; ostium in membrane near posterior margin of seventh sternum; ostial membrane microtrichiate; two shallow and dentate invaginations within membrane near posterolateral margin of seventh sternum; antrum membranous, short, forming a common inception for ductus seminalis and ductus bursae; ductus bursae long with two rows of platelike sclerotizations within anterior end; corpus bursae membranous, signum hornlike.

Types.—*Auximobasis normalis* Meyrick, Lectotype ♂, designated by Clarke (1963). "Lectotype" [disc label], "Huigra, 4500 f[ee]t, Ecuador, Parish, 6–14, Lectotype, *Auximobasis normalis* Meyrick, JFGC [larke], 1948" [hand-written label], "♂ genitalia on slide 5-X-1948, JFGC[larke] 8077" [hand-written label], "*Auximobasis normalis* Meyr., 15/1, E. Meyrick det. in Meyrick Coll[ection]" [hand-written label], "*normalis* Meyr." [hand-written label], "Meyrick Coll[ection], BM 1938-290". *Blastobasis crotospila* Meyrick, Holotype ♂, "Type, HT" [disc label], "James Island, Galapagos, at light, sea level, 26-7-[19]24, S[ain]t George Exped[itio]n, CL Collenette", "Brit[ish] Mus[eum] 1925-488", "M-48", "*Blastobasis crotospila* Meyr., Tr. Ent. Soc. Lond., p. 278(1926), Type ♂" [hand-written label]. "BM ♂ genitalia slide no. BM 27204". Specimen is missing apical portion of both antennae, right labial palpus, right foreleg, and both midlegs.

Other specimens Examined.—Española: 1 ♂, "ECUADOR, GALAPAGOS, Española, Bahía Manzanillo, 25/IV/1992, MVL, leg. B. Landry", "♂ genitalia slide by D. Adamski 3304" [green label], 1 ♀ with same data as above except, "29/IV/1992", "♀ genitalia slide by D. Adamski 3303" [green label]. Fernandina: 1 ♂, 4 ♀, "ECU[ADOR], GALAPAGOS, Fernandina, Punta Espinosa, 12/V/1992, MVL, leg. B. Landry"; 1 ♀ with same data as above except, "♀ genitalia slide by D. Adamski 3308" [green label]. Floreana: 1 ♂, "ECU[ADOR], GALAPAGOS, Punta Cormoran, 21/IV/1992, MVL, leg. B. Landry"; 1 ♂, 2 ♀ with same data as above except, "23/IV/1992". Genovesa: 2 ♂, "ECU [ADOR], GALAPAGOS, Genovesa, Bahía Darwin, 26/III/1992, MVL, leg. B. Landry" "♂ genitalia slides by D. Adamski 3305", and "3306", [green labels]; 2 ♀, same data as above except, "25/III/1992"; 7 ♀, same data as above except, "♀ genitalia slide by D. Adamski 3301", "3302", and "3307" [green labels]. Isabela: 2 ♂, 1 ♀, "ECUADOR, GALAPAGOS, Isla Isabela, Puerto Villamil, 2/III/1989, MVL, B. Landry", "♂ genitalia slide by D. Adamski, 3157" [green label]; 1 ♂, "1 km W Puerto Villamil, 3/III/1989"; ♂, 2 ♀, "2 km W Puerto Villamil, 5/III/1989", "♀ genitalia slide by D. Adamski 3313" [green label]; 2 ♀, "3 km N S[an]to Tómas Agr[icultural] Zone, 8/III/1989, MVL, B. Landry", "♀ genitalia slide by D. Adamski 3319" [green label]; 3 ♂, "11 km N P[uer]to Villamil, 9/III/1989"; 1 ♂, 1 ♀, "8.5 km N P[uer]to Villamil, 11/III/1989", and "13/III/1989"; 1 ♀, "Tagus Cove, 13/V/1992"; 3 ♀, "V[olcan] Darwin, 300m elev[ation], 15/V/1992"; 2 ♀, "V[olcan] Darwin, 1240m elev[ation], 19/V/1992", "♀ genitalia slide by D. Adamski 3315" [green label]. 1 ♀, "V[olcan] Darwin 630m elev[ation], 17/V/1992". Marchena: 2 ♂, "ECU[ADOR], GALAPAGOS, Marchena, MVL, 12/III/1992, leg. B. Landry"; 1 ♀ with same data as above except, "12/III/1992", "♀ genitalia slide by D. Adamski 3316" [green label]. Pinta: 1 ♂, "ECU[ADOR], GALAPAGOS, Pinta, 13/III/1992, Plaja Ibbeston, MVL, leg. B. Landry"; 1 ♂, 1 ♀, same data as above except, "14/III/1992"; 2 ♂, "15/III/1992, arid zone", "♂ genitalia slide by D. Adamski 3309" [green label]; 1 ♀, "16/III/1992, 200m elev[ation]"; 2 ♀, "17/III/1992,



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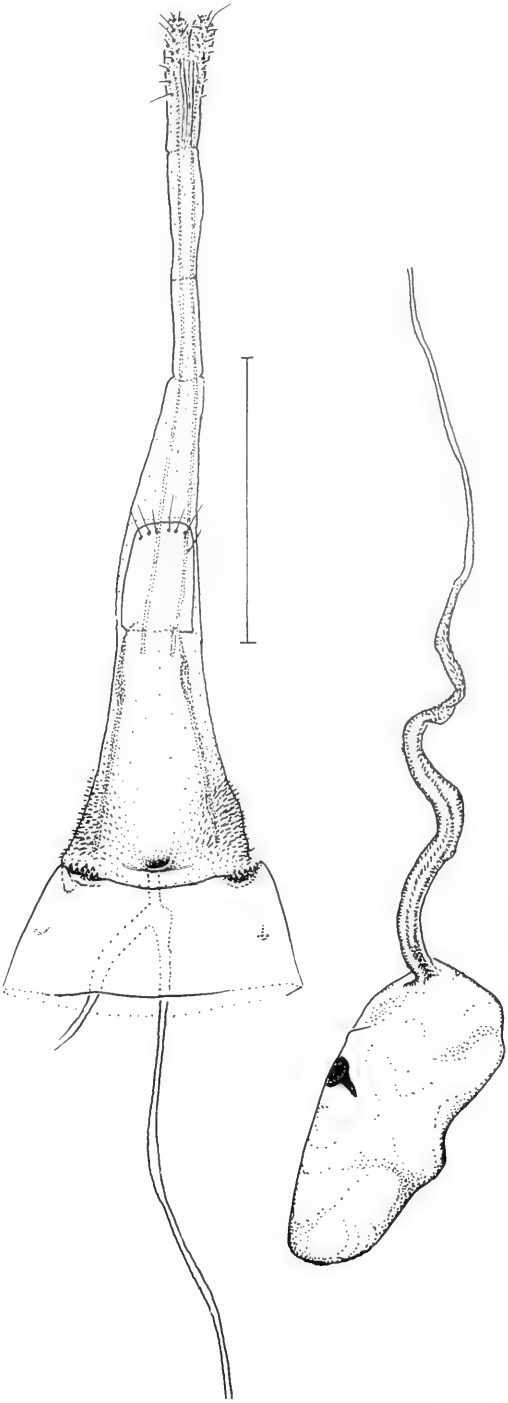

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Figs. 14–15. Female genitalia. 14, *Calosima darwini*. 15, *Blastobasis normalis*. Line scale = 1.0 mm.

400m elev[ation]", "Wing slide by D. Adamski, 3351" [green label]; 1 ♂, "18/III/1992, 400m elev[ation]", "♂ genitalia slide by D. Adamski 3310" [green label]; 2 ♂, "21/III/1992, (+, −) 15m elev[ation]". San Cristóbal: 2 ♀, "ECUADOR, GALAPAGOS, San Cristobal, 2 km SW P[uer]to Baquarizo [sic], 11/II/1989, MVL, B. Landry". The following specimens with same data as above except, 5 ♀, "14/II/1989", "17/II/1989", 2 ♀, "18/II/1989", "22/II/1989"; 3 ♂, "4 km SE P[uer]to Baquarizo [sic], 12/II/1989", "♂ genitalia slide by D. Adamski 3311" [green label]; 4 ♂, "1 km SE El Progreso, 14/II/1989", "♂ genitalia slide by D. Adamski 3300" [green label]; 1 ♂, "pampa zone, 15/II/1989"; 1 ♂, "P[uer]to Baquarizo [sic], 17/II/1989"; 2 ♂, "pampa zone, 18/II/1989"; 3 ♂, "4 km SE P[uer]to Baquarizo [sic], 20/II/1989"; 2 ♂, "base of Cerro Pelado, 22/II/1989", "♂ genitalia slide by D. Adamski 3356" [green label]; 1 ♂, "2 km SW P[uer]to Baquarizo [sic], 11/II/1989", "♂ genitalia slide by D. Adamski 3299" [green label]; 1 ♂, same data as above except, "20/II/1989". Santa Crúz: 6 ♂, 2 ♀, "ECUADOR, GALAPAGOS, 4 km N Puerto Ayora, 20/I/1989, MVL, B. Landry" "♂ genitalia slide by D. Adamski 3292" and "3158" [green labels], "♀ genitalia slide by D. Adamski 3289", and "3290" [green labels]; 1 ♂, "Los Gemelos, 31/I/1989"; 2 ♂, 9 ♀, "Tortuga Res[erve] W S[an]ta Rosa, 6/II/1989, MVL, B. Landry", "♂ genitalia slides by D. Adamski 3296", and "3298" [green labels], "♀ genitalia slides by D. Adamski 3159", "3291", and "3297" [green labels]; 3 ♂, 2 ♀, "2 km W Bella Vista, 27/II/1989", "♂ genitalia slide by D. Adamski 3294" [green label], "♀ genitalia slide by D. Adamski 3295" [green label]; 1 ♂, 1 ♀, "Finca S Devine, 17/III/1989". Santiago: 3 ♂, "ECU[ADOR], GALAPAGOS, Santiago, Bahia Espumilla, 4/IV/1992, MVL, leg. B. Landry"; 2 ♂, 4 ♀, same data as above except, "200m elev[ation], 5/IV/1992"; 2 ♂, 1 ♀, "Aguacate, 520m elev[ation], 6/IV/1992", "7/IV/1992", and "12/IV/1992"; 1 ♂, "Central, 700m elev[ation], 9/IV/1992"; 1 ♂, 2 ♀, "Cerro Inn, 28/III/1992".

Remarks.—*Blastobasis normalis* is not endemic to the Galápagos Islands as once thought. This species is now known to occur on the Ecuadorian mainland as well.

DISCUSSION

Adamski (*in* Adamski and Brown, 1989) provided a phylogenetic classification for the North American Blastobasinae that included evidence for the monophyly of both *Blastobasis* Zeller and *Calosima* Dietz. *Blastobasis normalis* shares all synapomorphies typical for the genus except the posterior lobe of the corpus bursae. Similarly, *Calosima darwini* shares all synapomorphies for the genus except an emarginate juxta, valva with secondary articulatory process, and absence of the proximal flange. Whether *Calosima darwini* is endemic to the Galápagos is questionable. This question can be reasonably addressed only after the fauna of Central and South America is better known.

ACKNOWLEDGMENTS

We thank K. Sattler, M. Shaffer and K. Tuck of The Natural History Museum, London, England, for loan of the lectotype of *Auximobasis normalis* Meyrick and holotype of *Blastobasis crotospila* Meyrick. The late Robert Silberglied provided specimens of *Calosima darwini* that he collected from the Galápagos Islands. We also thank the authorities of the Ecuadorian Ministry of Agriculture, the Galápagos National Park, and the Charles Darwin Research Station for kindly allowing field work and providing logistical support to B. Landry in 1989 and 1992. Joyce Cook, Moraima Inca, Ricardo Palma, Stewart B. Peck, Bradley J. Sinclair and Edwardo Vilema were excellent and most helpful companions. Finally, we are extremely grateful to Stewart B. Peck, Carleton University, Ottawa, Canada, for providing financial support for field work and costs of reprints through an operating grant for field research on arthropod evolution from the Natural Sciences and Engineering Research Council of Canada.

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STUDIES IN AQUATIC INSECTS XII: DESCRIPTIONS OF NINETEEN NEW SPECIES OF THE GENUS *OCHROTRICHIA* MOSELY (TRICHOPTERA: HYDROPTILIDAE) FROM MEXICO AND CENTRAL AMERICA

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Abstract.—Nineteen new species of the genus *Ochrotrichia* Mosely from Mexico and Central America are described and the male genitalia figured: **O. ixcateopana** (Mexico); **O. crucecita** (Panama); **O. arriba** (Panama); **O. zihuaquia** (Mexico); **O. blanca** (Belize); **O. maycoba** (Mexico); **O. eyipantla** (Mexico); **O. glabra** (Panama); **O. hondurenia** (Belize); **O. corneolus** (Panama); **O. anomala** (Panama); **O. bicaudata** (Panama); **O. regina** (Panama); **O. lupita** (Panama); **O. maya** (Mexico); **O. palmata** (Mexico); **O. serrana** (Mexico); **O. poblana** (Mexico); and **O. velascoi** (Mexico). This genus has a wide distribution, from southern Canada south throughout Mexico and Central America, the West Indies, and South America.

Key Words: taxonomy, *Ochrotrichia*, Trichoptera, Hydroptilidae, Mexico, Central America

The genus *Ochrotrichia* Mosely of the Neotropical Region has been studied by Mosely (1937), Denning and Blickle (1972), Bueno and Santiago (1981, 1992) and Flint (1972). However, in Mexico, Central, and South America there are still many undescribed species.

This genus was previously divided into the subgenera *Ochrotrichia* and *Metrichia* by Flint (1972) because of his belief that the larvae of both genera were indistinguishable, but the adults were quite distinct. However, Wiggins (1996) found a number of characters which separate larvae of *Ochrotrichia* from *Metrichia* and considered them as distinct genera; we follow this concept. The adult of *Ochrotrichia* lacks an apical spur on the foreleg, and the male lacks modifications on the abdomen and possesses genitalia with a large, often extremely modified tenth tergum and a rather simple phallus. *Metrichia* has an apical spur on the foreleg, the abdomen often possesses internal sacs and/or setal brushes, and the male genitalia has the tenth tergum reduced to a simple membranous lobe, a button-like cercus, dorsolateral hooks, and a very large phallus, usually with two large hooks.

Most of the species of *Ochrotrichia* here described, were provided by Dr. Oliver S. Flint, Jr. from the collection of the National Museum of Natural History (NMNH) where they will be deposited. The rest of the species, will be deposited in the collection of the Instituto de Biología UNAM (IBUNAM).

Family Hydroptilidae

In Mexico, Central, and South America there are representatives of all six tribes: Leucotrichiini, Stactobiini, Neotrichiini, Ochrotrichiini, Orthotrichiini and Hydroptiliini all in the subfamily Hydroptilinae (Marshall 1979). The genus *Ochrotrichia,* belonging to the tribe Ochrotrichiini, is well represented in the tropical rain forests of Mexico, Central, and South America (Bueno and Santiago 1992).

Flint (1972), divided the genus *Ochrotrichia* Mosely into two major groups, one, the *xena* group, which is characterized by a simple ninth segment and the tenth tergum being a simple flap often with a few small spines. The other major group is characterized by the ninth tergum depressed below the dorsal margin of the pleura and the anterior margin is produced beyond the anterior margin of the pleura. The tenth tergum is more or less fused with the ninth tergum and appears greatly modified, bearing many spines, processes and plates. This second major group was divided by Flint (1972) into six subgroups, on the basis of the shape of the tenth tergum, inferior appendages and phallus.

Genus *Ochrotrichia* Mosely

Polytrichia Sibley 1926:102.—Betten 1934:153.—Mosely 1937:184.—Ross 1944:125. Type species: *Ithytrichia confusa* Morton 1905, monobasic [preocupied].

Ochrotrichia Mosely 1934:162.—Ross 1944:125.—Denning 1956:255.—Flint 1964:58; 1968a:48; 1968b:59. Type species *Ochrotrichia insularis* Mosely, 1934, by original designation.

Ochrotrichia ixcateopana Bueno and Santiago, new species

(Figs. 1–3)

On the basis of the shape of the inferior appendages in lateral view and because of the presence and distribution of the processes of the tenth tergum, *O. ixcateopana* belongs to the group of species related to *O. dactylophora* Flint, from which it differs in the long process of the inferior appendages and features of the tenth tergum.

Adult.—Length of forewing 2.5 mm. Color in alcohol dark brown. Male genitalia: ninth tergum depressed and produced anteriad. Tenth tergum with two spines on right side, lateralmost shorter, and other long and curved ventrally; centrally with basal middorsal process having two upturned spines at apex. Inferior appendages asymmetrical, both with heavy, black, posterior spines; left inferior appendage with row of three short spines in midsection of posterior border; right inferior appendage with two, black, short, robust spines. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Guerrero, 7 km Route Taxco-Ixcateopan, 17 June 1987, J. Bueno, H. Brailovsky and E. Barrera (IBUNAM).

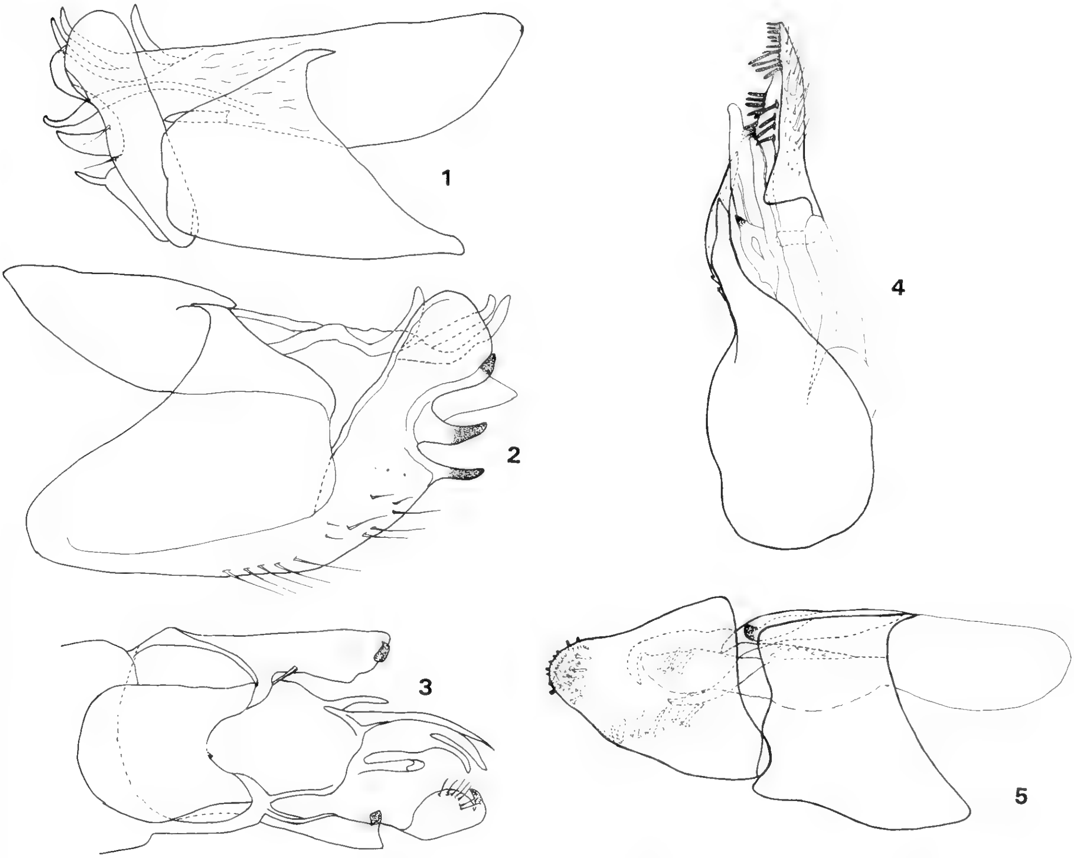
Etymology.—Named for Ixcateopan, Guerrero, the area where the type was collected.

Ochrotrichia crucecita Bueno and Santiago, new species

(Figs. 4–5)

This species appears to be closely related to *Ochrotrichia cruces* Flint. However, it is distinguished from that species by the presence of two spines on the right side of the tenth tergum in lateral view: one being short, stout, basodorsal, curved ventrally and the other long and curved ventrally, and by the lack of the third small, thin, spine on the right side, which is present in *O. cruces.*

Adult.—Length of forewing 3 mm. Color in alcohol dark brown. Male genitalia: ninth segment with short, broad posterodorsal lobe, in lateral aspect deeply depressed and produced anteriad. Tenth tergum complex in dorsal view, with an elongate, black-tipped process arising basolaterally on right side curving to left side; a short, black-tipped, middorsal, upcurved spine and a robust spine situated dorsolaterally; apical process with tip hooked ventrad; in lateral aspect elongate, black-tipped process appears curved and ventrally situated to rest of structures; in this view, a short, black-tipped, middorsal, spine appears situated behind a robust, dorsolaterally situated spine. Inferior appendages broadly triangular, apex rounded, with a band of black,



Figs. 1–5. 1–3, *Ochrotrichia ixcateopana,* male genitalia. 1, Right side. 2, Left side. 3, Dorsal. 4–5, *O. crucecita,* male genitalia. 4, Dorsal. 5, Lateral.

peglike setae apically and on midbasal ridge, one more cluster near dorsal margin. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA: Chiriqui, Guadalupe Arriba 8°52′26″N: 82°33′13″W, 2–8 May 1984, H. Wolda (NMNH). Paratypes: same as holotype but 3–9 July 1985, 1 ♂ (NMNH); same as holotype but 24–30 July 1985, 1 ♂ (NMNH).

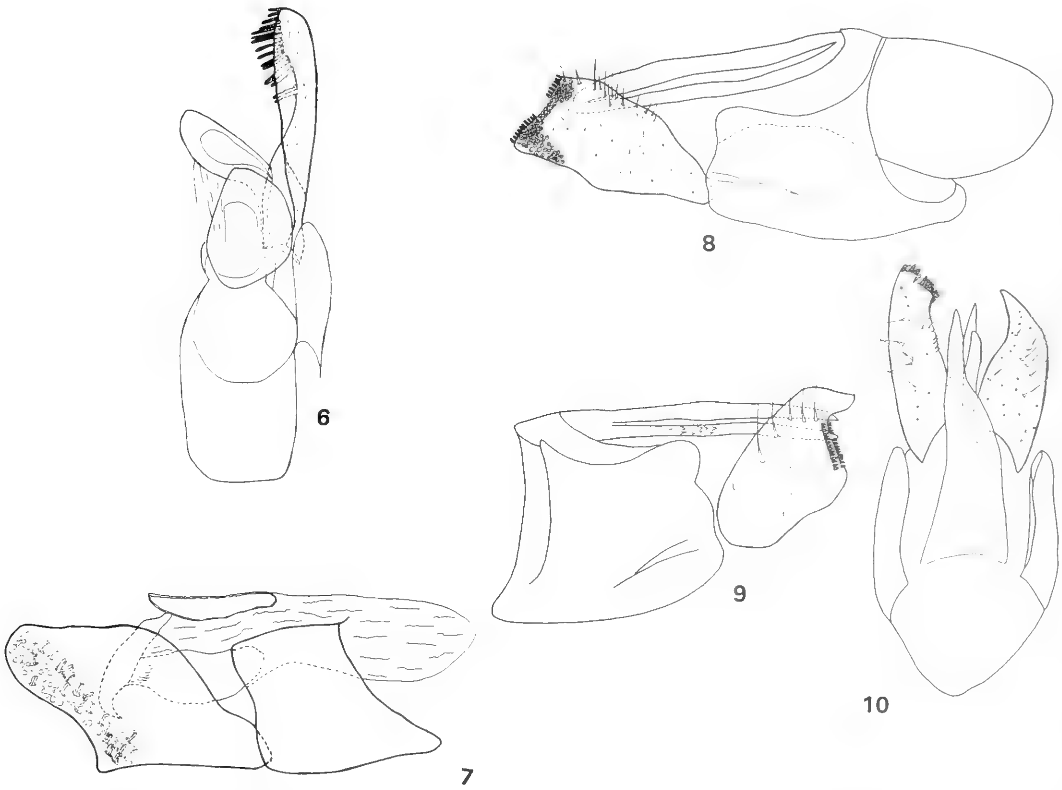
Etymology.—*crucecita:* diminutive in Spanish for little cross.

Ochrotrichia arriba Bueno and Santiago, new species
(Figs. 6–7)

On the basis of the shape of the inferior appendages in lateral aspect, this species could be considered related to *Ochrotrichia aldama* (Mosely). However, the tenth tergum of *O. arriba* is formed by two short, rounded plates in dorsal view, a character distinctly different from *O. aldama.*

Adult.—Length of forewing 3 mm. Color in alcohol dark brown. Male genitalia: ninth tergum deeply depressed and produced anteriad. Tenth tergum in dorsal aspect like a simple, broad, elongate flap with a rounded, ringlike area anteriad and a curved and narrowed posterior plate; in lateral aspect apex of posterior plate appears curved ventrad. Inferior appendages in lateral view rectangular, broad and with small posteroventral lobe; posterior margin with a band of black, peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA:



Figs. 6–10. 6–7, *Ochrotrichia arriba,* male genitalia. 6, Dorsal. 7, Lateral. 8–10, *O. zihuaquia,* male genitalia. 8, Right side. 9, Left side. 10, Dorsal.

Chiriqui, Guadalupe Arriba, 8°52′26″N 82°33′13″W, 3–9 July 1985, H. Wolda (NMNH).

Etymology.—*arriba:* Spanish for above.

Ochrotrichia zihuaquia Bueno and Santiago, new species
(Figs. 8–10)

On the basis of the shape of the inferior appendages, this species appears to be related to *Ochrotrichia insularis* Mosely, but the distinct processes on the tenth tergum, resemble those of *Ochrotrichia aldama* (Mosely).

Adult.—Length of forewing 2.9 mm. Color in alcohol dark brown. Forewing with a transverse, white band at midlength. Male genitalia: ninth segment open dorsally, slightly produced anteriad. Tenth tergum mostly membranous with three long processes almost of equal length; in lateral aspect apparently with two long processes with acute apices; process on left side with a group of small spines. Inferior appendages short and wide with cluster of thick, long, dark spines on mesal face at apex; in dorsal aspect, appendages asymmetric, left appendage with long, apicodorsal process, right appendage with posterior margin swollen and covered with peglike seta. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Guerrero, route 134, 102 km N. W. of Zihuatanejo, 1200 m, 7 June 1984, J. Bueno and E. Marino (IBUNAM). Paratypes: MEXICO: Oaxaca, Candelaria de Loxicha, Finca Pacifica, 510 M elevation, 2 June 1985, E. Barrera 1 ♂ (IBUNAM) and 1 ♂ (NMNH).

Etymology.—Named from the place where the type was collected in Zihuaquio, Guerrero.

Ochrotrichia blanca Bueno and Santiago, new species

(Figs. 11–13)

This species and the two subsequent species, on the basis of shape of the inferior appendages in lateral aspect and the presence of long processes on the right side of the tenth tergum, appear to be related. However, *Ochrotrichia blanca* differs from these species by the presence of a short middorsal spine and by the distribution of the five long processes on the tenth tergum.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth segment deeply depressed and produced anteriad. Tenth tergum in dorsal view, with a long dorsalmost process on left side, with a short middorsal spine; on right side with two, long, curved processes, left one wider than right one which appears narrowed, both with apex acute and convergent; in lateral view ventral plate appears U-shaped on left side. Inferior appendages elongate, broadest apically; in lateral aspect slightly triangular; posterior border with many black, peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: BELIZE: Cayo District, Rio Privassion, Blancaneaux Lodge, 9–11 July 1973, Y. Sedman (NMNH).

Etymology.—*blanca:* feminine, white in Spanish.

Ochrotrichia maycoba Bueno and Santiago, new species

(Figs. 14–16)

This species appears related to *Ochrotrichia blanca* and *O. eyipantla.* Because of the distribution of the processes of the tenth tergum, and the shape of inferior appendages, *O. maycoba* also shows a relationship with the species of the *confusa* complex.

Adult.—Length of forewing 3 mm. Color in alcohol pale brown. Male genitalia: ninth tergum deeply depressed and slightly produced anteriad. Tenth tergum with five elongate processes; two processes on left side and three on right side, dorsalmost one appears widest and slightly curved to right; underneath these five processes a long process ending in a sclerotized, hook-like apex. Inferior appendages broadly triangular, with one broad, posterodorsal process in lateral aspect; right appendage with a posterior, apically situated, patch of black peglike setae; left appendage with apical row of black peglike setae and a fingerlike process on posterodorsal corner. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Sonora, Maycoba River, west of Maycoba, 21 August 1986, R. Baumann, Sergeant & Kondratieff (NMNH).

Etymology.—Named for the Maycoba River where the holotype was collected.

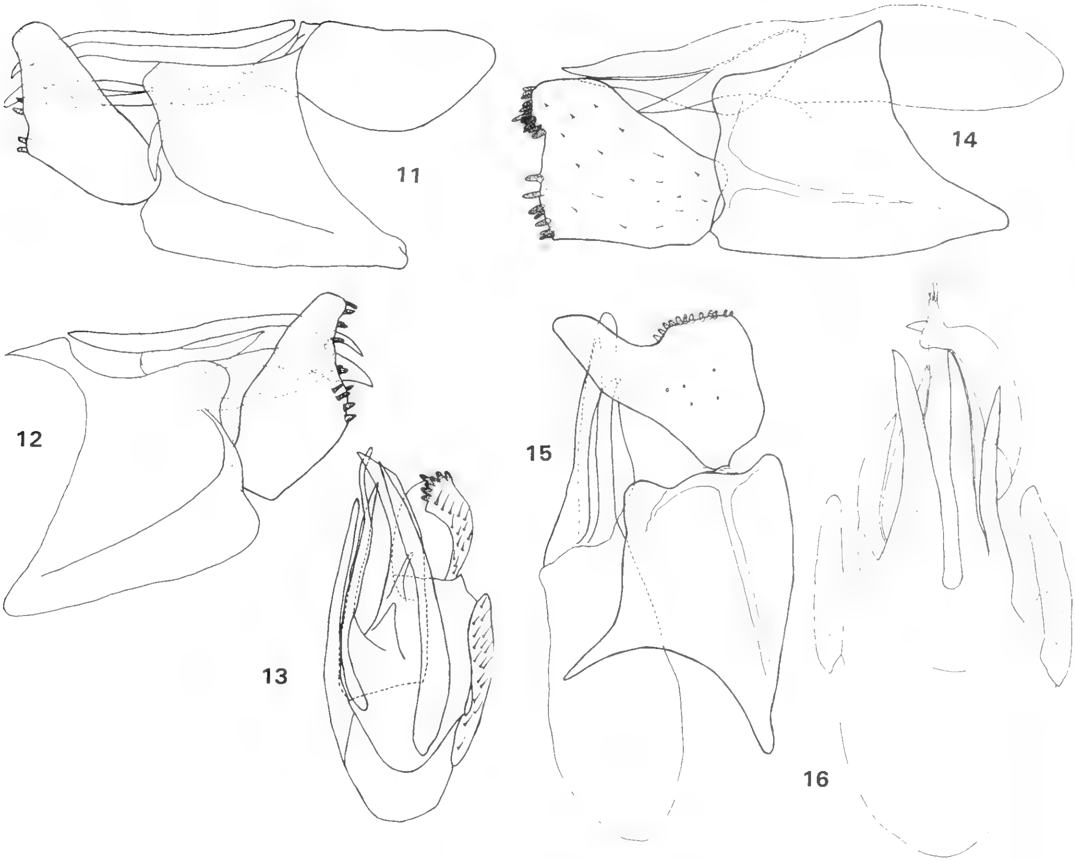
Ochrotrichia eyipantla Bueno and Santiago, new species

(Figs. 17–19)

On the basis of the shape and distribution of the processes of the tenth tergum, this species appears to be related to *Ochrotrichia maycoba.* However, *Ochrotrichia eyipantla* can be separated from this species by the presence of only four spinelike processes on the tenth tergum, and by the differences in shape and size of the inferior appendages.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth tergum slightly depressed and slightly produced anteriad. Tenth tergum in dorsal aspect with a long, wide, and laterally-situated process, whose apex touches the apical hooklike portion of ventralmost process which is widened at midlength; with four shorter middorsal spinelike processes, lateralmost on right side shorter than lateralmost on left side, one of middorsal spinelike processes slightly curved; in lateral view on right side with a straight spinelike process. Inferior appendages broadly triangular, with apical row of black peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Veracruz, Salto de Eyipantla, Eyipantla River,



Figs. 11–16. 11–13, *Ochrotrichia blanca,* male genitalia. 11, Right side. 12, Left side. 13, Dorsal. 14–16, *O. maycoba,* male genitalia. 14, Right side. 15, Left side. 16, Dorsal.

30 March 1990, P. J. Spangler and S. Santiago-Fragoso (IBUNAM).

Etymology.—Named from Eyipantla, a waterfall in Veracruz, where the holotype was collected.

Ochrotrichia glabra Bueno and Santiago, new species
(Figs. 20–21)

On the basis of the shape of the tenth tergum, *Ochrotrichia glabra* appears most similar to *Ochrotrichia hondurenia.* However, *O. glabra* can be separated from that species by the lack of stout peglike spines on the tenth tergum.

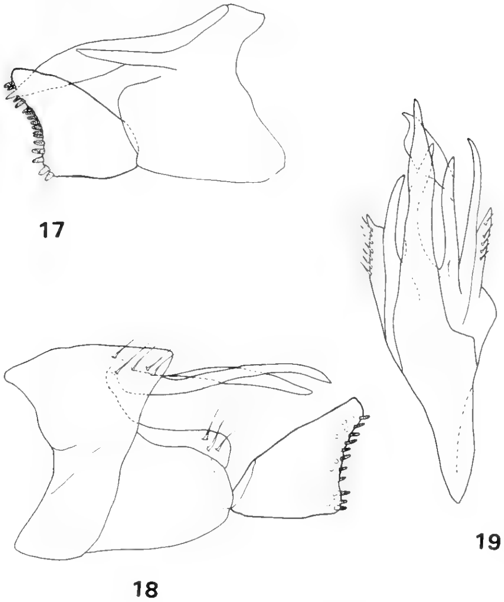
Adult.—Length of forewing 2 mm. Color in alcohol dark brown. Male genitalia: ninth segment deeply depressed and slightly produced anteriad. Tenth tergum a simple, elongate, glabrous lobe, with apex rounded. Inferior appendages rectangular and elongate, apex broad and rounded; with cluster of black peglike setae at apex and another group near ventral margin; midbasal ridge obsolescent. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA, Chiriqui, Guadalupe Arriba, 8°52′26″N and 82°33′13″W, 30 October–5 November 1985, H. Wolda (NMNH).

Etymology.—*glabra:* Latin for hairless, smooth, relating to the tenth tergum.

Ochrotrichia hondurenia Bueno and Santiago, new species
(Figs. 22–23)

On the basis of the tenth tergum, this species appears related to *Ochrotrichia glabra.*



Figs. 17–19. *Ochrotrichia eyipantla,* male genitalia. 17, Right side. 18, Left side. 19, Dorsal.

However, because of the presence of three, stout, darkened, apically-situated, peglike processes on the tenth tergum and two long filaments on the apical portion of the phallus, *Ochrotrichia hondurenia* is easily distinguished.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth segment deeply depressed and produced anteriad. Tenth tergum a broad, elongate plate, with three stout, darkened, apically-situated, peglike processes; with left and right side sclerotized, but membranous centrally. Inferior appendages elongate, apex rounded; with a row of black peglike setae around apex and along ventral margin. Phallus tubular with a conically expanded base; apex with two processes, one straight and another gradually decurved.

Material.—Holotype, ♂: BELIZE: Cayo District, Mountain Pine Ridge, 27 June 1971, G. Stacell (NMNH).

Etymology.—Named for the former British Honduras, the country where the holotype was collected.

Ochrotrichia corneolus Bueno and Santiago, new species

(Figs. 24–25)

On the basis of the elongate shape of the inferior appendages and the presence of one short, strong, basodorsal spine, on the tenth tergum, this species is related to *Ochrotrichia stylata* (Ross). However, *O. corneolus* can be separated from that species by the shape of the curved, basodorsal spine on the tenth tergum.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth tergum with rounded posterodorsal lobe in lateral aspect, deeply depressed and slightly produced anteriad. Tenth tergum a narrow, elongate plate with apex upturned; dorsally with a short, single, sinuate, basal spine; underneath plate on left side arises a long spinelike process with its apex a little longer than plate. Inferior appendages elongate, narrow, apex rounded with a row of black, peglike setae apically, along the ventral margin and midbasal ridge. Phallus long and threadlike.

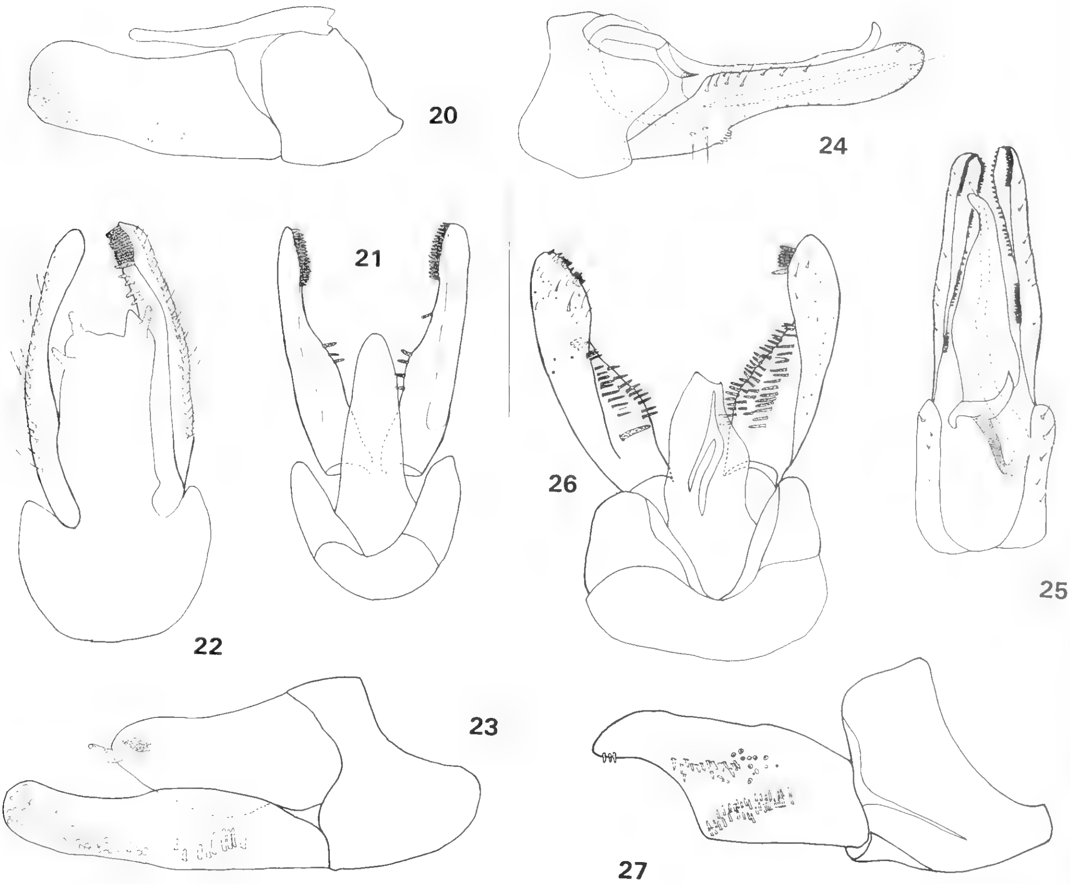
Material.—Holotype, ♂: PANAMA: Barro Colorado Island, Snyder-Molino Trail, Marker 3, Trap Level III, 18–24 November 1987, H. Wolda (USNM). Paratypes: same as holotype, 1 ♂ (NMNH); same but 3–9 June 1987, 1 ♂ (NMNH); same but 25 November–1 December 1987, 1 ♂ (NMNH); same but 2–8 December 1987, 1 ♂ (NMNH); same but 19–25 October 1988, 1 ♂ (NMNH); same but 10–16 May 1989, 1 ♂ (NMNH); same but 21–27 June 1989 1 ♂ (NMNH); same but 13 September 1989, 1 ♂ (NMNH); same but 22–28 November 1989, 1 ♂ (NMNH); same but 29 November–5 December 1989, 1 ♂ (NMNH); same but 6–12 December 1989, 1 ♂ (IBUNAM).

Etymology.—*corneolus:* Latin for a diminutive horn.

Ochrotrichia anomala Bueno and Santiago, new species

(Figs. 26–27)

On the basis of the shape of the inferior appendages and tenth tergum, this species



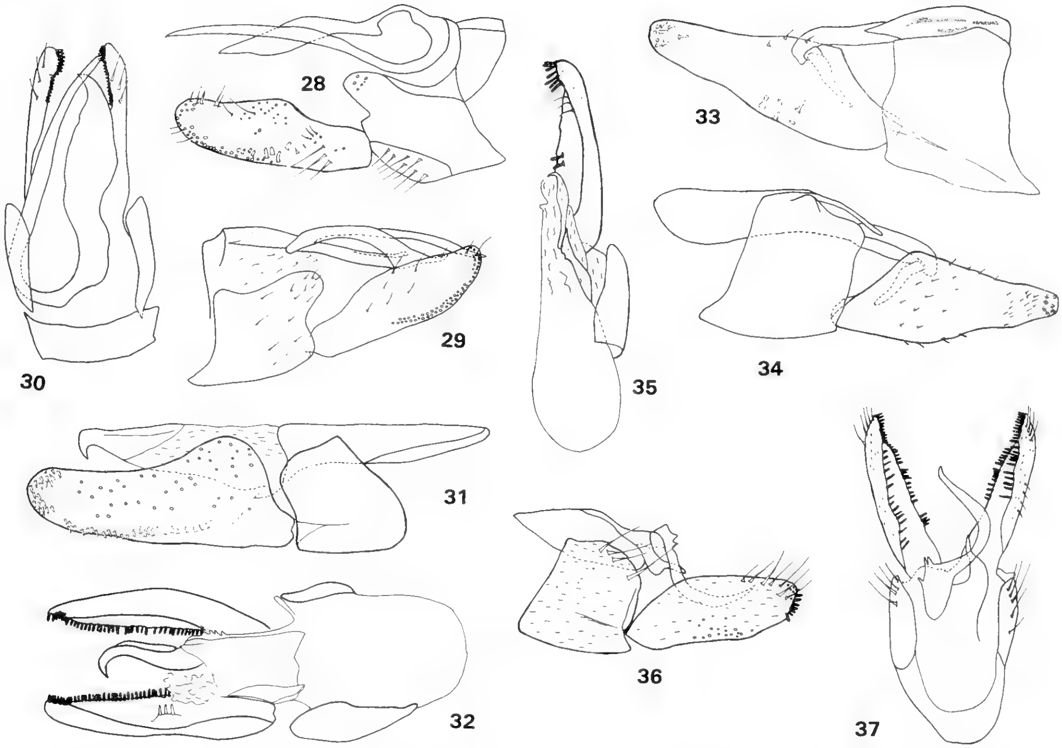
Figs. 20–27. 20–21, *Ochrotrichia glabra,* male genitalia. 20, Right side. 21, Dorsal. 22–23, *O. hondurenia,* male genitalia. 22, Dorsal. 23, Lateral. 24–25, *O. corneolus,* male genitalia. 24, Left side. 25, Dorsal. 26–27, *O. anomala,* male genitalia. 26, Dorsal. 27, Right side.

may be related to *Ochrotrichia flagellata* Flint, from which it can be separated by the presence of sclerotized bars on the tenth tergum, and by the lightly rectangular shape of the ninth segment in lateral aspect.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth segment deeply depressed and slightly produced anteriad, in lateral aspect appearing triangular. Tenth tergum a membranous hood, dorsally with a pair of sclerotized, sinuous bars. Inferior appendages long, slender, apex rounded with a mesal cluster of black peglike setae; a high dorsal lobe, with a row of black peglike setae at margin of apex. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA: Barro Colorado Island, Snyder-Molino Trail, Marker 3, trap level III, 18–24 November 1987, H. Wolda (NMNH). Paratypes: same as holotype but 7–13 October 1987, 1 ♂ (NMNH); same but 18–25 October 1988, 1 ♂ (NMNH); same but 16–22 November 1988, 1 ♂ (NMNH); same but 23–29 November 1988, 1 ♂ (NMNH); same but 8–14 February 1989, 1 ♂ (NMNH); same but 11–17 October 1989, 1 ♂ (NMNH); same but 7–13 November 1990, 1 ♂ (NMNH); same but 19–25 December 1990, 1 ♂ (IBUNAM).

Etymology.—*anomala:* means abnormal in Spanish.



Figs. 28–37. 28–30, *Ochrotrichia bicaudata,* male genitalia. 28, Right side. 29, Left side. 30, Dorsal. 31–32, *O. regina,* male genitalia. 31, Right side. 32, Dorsal. 33–35, *O. lupita,* male genitalia. 33, Right side. 34, Left side. 35, Dorsal. 36–37, *O. maya.* 36, Left side. 37, Dorsal.

Ochrotrichia bicaudata Bueno and Santiago, new species
(Figs. 28–30)

On the basis of the shape of the inferior appendages and the tenth tergum, this species appears similar to *Ochrotrichia aldama* (Mosely). However, *O. bicaudata* is recognized by the presence of two, long, slender processes on the tenth tergum.

Adult.—Length of forewing 2 mm. Color in alcohol pale brown. Male genitalia: ninth tergum deeply depressed and produced anteriad in lateral aspect, with rounded posterodorsal lobes. Tenth tergum with two, long, slender processes, one appears sinuous and wider with apex curving to right; on right side a slightly-curved, long process, with apex directed ventrad. Inferior appendages elongate, with rounded apex; apex, ventral margin and midbasal ridge with many, short, black, peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA: Barro Colorado Island, Snyder-Molino Trail, Marker 3, trap level III, 2–8 December 1987, H. Wolda (NMNH). Paratypes: Same as holotype, 1 ♂ (NMNH); same but 11–17 March 1987, 1 ♂ (NMNH); same but 7–13 October 1987, 1 ♂ (NMNH); same but 4–10 November 1987, 1 ♂ (NMNH); same but 18–24 November 1987, 3 ♂ (NMNH); same but 16–22 November 1988, 1 ♂ (NMNH); same but 30 November–6 December 1988, 1 ♂ (NMNH); same but 7–13 December 1988, 2 ♂ (NMNH); same but 4–10 January 1989, 1 ♂ (NMNH); same but 11–17 January 1989, 1 ♂ (NMNH); same but 1–7 February 1989, 1 ♂ (NMNH); same but 6–12 December 1989, 1 ♂ (NMNH); same but 13–19 December 1989, 1 ♂ (NMNH); same but 8–14 August 1990, 1 ♂ (NMNH); same but 22–28 August 1990, 1 ♂ (NMNH); same but 12–18 September 1990, 1 ♂ (NMNH); same but 17–23 October 1990, 1 ♂ (NMNH); same but 16–22 January 1991, 1 ♂ (IBUNAM).

Etymology.—*bicaudata:* Latin, for the two processes of the tenth tergum.

Ochrotrichia regina Bueno and Santiago, new species

(Figs. 31–32)

Because of the membranous and elongate aspect of the tenth tergum, this species appears related to *Ochrotrichia lupita.* However, the presence of one, curved, spinelike process apically on the tenth tergum easily distinguishes *Ochrotrichia regina.*

Adult.—Length of forewing 2 mm. Color in alcohol dark brown. Male genitalia: ninth tergum deeply depressed and produced anteriad; in lateral aspect appearing almost quadrangular. Tenth tergum with short, basal, middorsal plate; apical process with tip pointed and curved to right; in lateral aspect with apex of apical process turned ventrally and slightly enlarged preapically. Inferior appendages in lateral view elongate, apex rounded; apex, ventral margin and midbasal ridge with with a band of black peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA: Barro Colorado Island, Snyder Molino trail, Marker 3, Trap level-I, 30 November–6 December 1988, H. Wolda (NMNH). Paratypes: Same as holotype, but 27 May–2 June 1987, 1 ♂ (NMNH); same but 5–11 August 1987, 1 ♂ (NMNH); same but 26 August–1 September 1987, 1 ♂ (NMNH); same but 16–22 September 1987, 1 ♂ (NMNH); same but 30 September–6 October 1987, 1 ♂ (NMNH) 1 ♂ (IBUNAM); same but 21–27 October 1987, 1 ♂ (NMNH); same but 4–10 November 1987 1 ♂ (NMNH); same but 18–24 November 1987, 1 ♂ (NMNH); same but 25 November–1 December 1987, 1 ♂ (NMNH); same but 2–8 December 1987, 1 ♂ (NMNH); same but 18–24 May 1988, 1 ♂ (NMNH); same but 9–15 November 1988, 2 ♂ (NMNH); same but 23–29 November 1988, 1 ♂ (NMNH); same but 26 April–2 May 1989, 1 ♂ (NMNH); same but 24–30 May 1989, 1 ♂ (NMNH); same but 30 August–5 September 1989, 2 ♂ (NMNH); same but 6–12 September 1989, 3 ♂ (NMNH); same but 22–28 November 1989, 2 ♂ (NMNH); same but 9–15 May 1990, 1 ♂ (NMNH); same but 13–19 June 1990, 1 ♂ (NMNH); same but 20–26 June 1990, 1 ♂ (NMNH); same but 27 June–3 July 1990, 1 ♂ (NMNH); same but 18–24 July 1990, 1 ♂ (NMNH); same but 8–14 August 1990, 1 ♂ (NMNH); same but 15–21 August 1990, 1 ♂ (NMNH); same but 22–28 August 1990, 1 ♂ (NMNH); same but 29 August–4 September 1990, 2 ♂ (NMNH); same but 12–18 September 1990, 1 ♂ (NMNH); same but 19–25 September 1990, 1 ♂ (NMNH); same but 26 September–2 October 1990, 1 ♂ (NMNH); same but 17–23 October 1990, 2 ♂ (NMNH); same but 31 October–6 November 1990, 1 ♂ (NMNH); same but 14–20 November 1990, 2 ♂ (NMNH); same but 21–27 November 1990, 2 ♂ (IBUNAM).

Etymology.—*regina:* Latin for queen.

Ochrotrichia lupita Bueno and Santiago, new species

(Figs. 33–35)

On the basis of the hook-shaped apex of the tenth tergum, this species is related to *Ochrotrichia regina.* However, *O. lupita* is easily distinguished by the lack of a broad, middorsal area on the tenth tergum.

Adult.—Length of forewing 3 mm. Color in alcohol dark brown. Male genitalia: ninth segment deeply depressed and produced anteriad. Tenth tergum with a short, basodorsal plate with a long, apical process whose apex curves ventrad; left side in lateral view with an elongate, spinelike process and underneath this a long, slightly sinuous, spinelike structure ventrally directed. Inferior appendages elongate, broad, apex rounded, with a cluster of black, peglike setae at apex and another group near ventral margin. Phallus long and threadlike.

Material.—Holotype, ♂: PANAMA: Chiriqui, Guadalupe Arriba, 8°52′26″N: 82°33′13″W, 3–9 July 1985, H. Wolda (NMNH). Paratype: same as holotype but 1–7 May 1985, H. Wolda. 1 ♂ (NMNH).

Etymology.—*lupita:* nickname in Spanish for Guadalupe.

Ochrotrichia maya Bueno and Santiago, new species

(Figs. 36–37)

Because the presence of two asymmetrical precesses on the tenth tergum, *Ochrotrichia maya* is not obviously related to any other species of this genus.

Adult.—Length of forewing, 2 mm. Color stramineous in alcohol. Male genitalia: ninth tergum depressed and produced anteriad. Tenth tergum divided into long and short processes; long process in left lateral view clearly curved with tip directed ventrally; in dorsal view with basal portion shieldlike, with three, short teeth on right; short process wider, with tip directed ventrad. Inferior appendages elongate, broad; with a band of black, peglike setae at apex and a group of peglike setae mesad. Phallus long and threadlike.

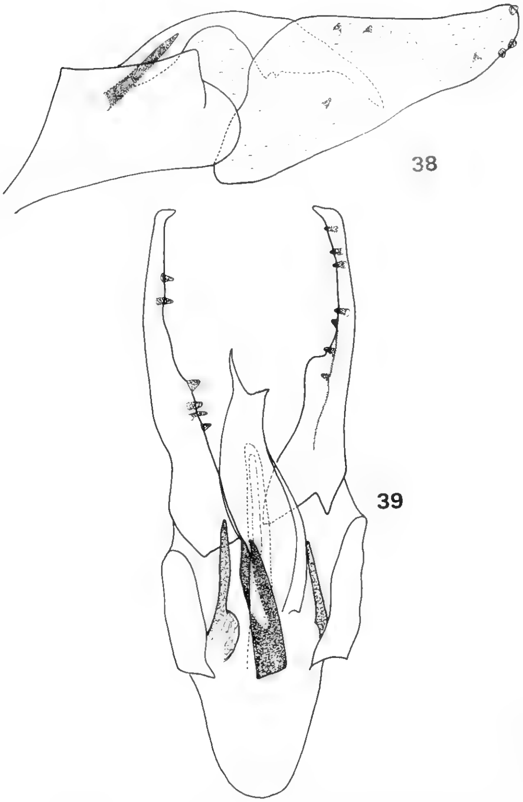
Material.—Holotype, ♂: MEXICO: Chiapas, Cascada de Misolja, 20 km. S. from Palenque, 17–18 May 1981, C. M. & O. S. Flint Jr. (NMNH). Paratype: Route 195, 1.5 mi. N. Ixhuatán, 23 December 1983. S. Hamilton, R. Holzenthal, M. Kovach, 1 ♂ (NMNH).

Etymology.—*maya:* Indian people living in the area where the type was collected.

Ochrotrichia palmata Bueno and Santiago, new species

(Figs. 38–39)

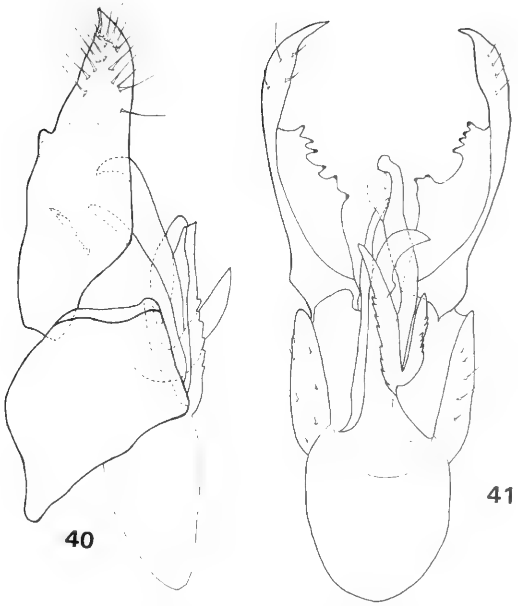
Because of the presence of short, stout, spines at the base of the tenth tergum, *Ochrotrichia palmata* may be related to *Ochrotrichia poblana* and *O. velascoi.* However, *O. palmata* can be recognized by the shape of the tenth tergum which appears palmate in lateral aspect.



Figs. 38–39. *Ochrotrichia palmata,* male genitalia. 38, Left side. 39, Dorsal.

Adult.—Length of forewing, 2.5 mm. Color dark brown in alcohol. Forewing with a transverse white band at midlength. Male genitalia: ninth segment open dorsally, produced anteriad; posterior margin sinuate. Tenth tergum in lateral aspect basally narrow, with curved midsection, apical process palmate, with a fingerlike, ventrally-curved process, and one, short, basal spine; in dorsal aspect, with sinuous, membranous process, surrounded by four short spines, centralmost black-tipped and covered by membranous, dorsal process. Inferior appendages, narrow, with rounded apex; apex of midbasal ridge with a line of black, peglike setae. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Es-



Figs. 40–41. *Ochrotrichia serrana,* male genitalia. 40, Right side. 41, Dorsal.

tado de Mexico, Temascaltepec, 8 February 1979, J. Bueno and J. Padilla (IBUNAM).

Etymology.—*palmata:* Latin for handshape, shown in the lateral aspect of the tenth tergum.

Ochrotrichia serrana Bueno and Santiago, new species
(Figs. 40–41)

On the basis of the shape and distribution of the processes of the tenth tergum, this species is similar to *Ochrotrichia chiapa* Denning. However, *Ochrotrichia serrana* differs from that species by the possession of a stout spine with denticuli on the dorsal margin and by the presence of a short, spinelike process on the left side of the base of tenth tergum.

Adult.—Length of forewing 2.5 mm. Color pale brown in alcohol. Male genitalia: ninth segment deeply depressed and produced anteriad. Tenth tergum in dorsal aspect with a basodorsal, stout process with dorsal edge serrate; two lateral spines on right side, dorsalmost wider and curved to left, ventralmost long and slender, ending with darkened apex; left side with a short, basolateral spine with dorsal margin serrate; long middventral process widened at midlength with tip rounded and curved to right. Inferior appendages in dorsal view with ventral margin bearing a line of peglike setae; in lateral view long and slender, apex acute. Phallus long and threadlike.

Material.—Holotype, ♂. MEXICO: Guerrero, Acahuizotla, 10 km E. of Chilpancingo, 10 November 1982, J. Bueno, E. Barrera and H. Brailovsky (IBUNAM).

Etymology.—*serrana:* Spanish name, given to women inhabitants of the mountains.

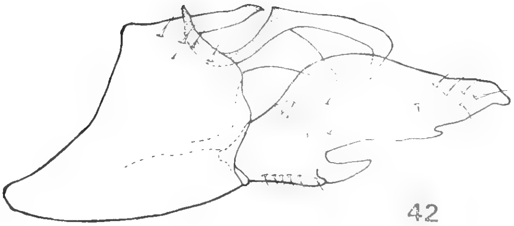
Ochrotrichia poblana Bueno and Santiago, new species
(Figs. 42–43)

On the basis of elongate inferior appendages, tapering to a pointed apex in lateral view, this species is related to the *lometa* group, especially with *Ochrotrichia oregona* Ross or *O. nacora* Denning and Blickle. However, *O. poblana* can be separated from these species, by the presence of stout, spinelike processes on both inferior appendages and, in lateral view, by the presence on the tenth tergum of one, dorsally curved, spinelike process on the left side, with two apices, one directed posteriad and one directed anteriad.

Adult.—Length of forewing 3 mm. Color in alcohol dark brown. Male genitalia: ninth segment incomplete dorsally, produced anteriad, with posterior border slightly sinuous in lateral aspect. Tenth tergum in dorsal aspect with a short, basodorsal spine arising from left side, curved apically; on right side with one, black, basodorsal spine barely passing left spine; a stout, dark-tipped process, attached in middle, with basal end curved upward and directed anteriad and distal end ventrally curved and directed posteriad. Left inferior appendage in dorsal aspect with a well developed midbasal, stout, black-tipped spine; right appendage with a short, basoventral spine and a midventral line of teeth; in lateral aspect a midventral, stout, dark-tipped spine; apex ending in a short, black, stout process. Phallus long and threadlike.

Material.—Holotype, ♂: MEXICO: Puebla, km 30, route Zacapoaxtla-Zacatlán, May 2 1987, J. Bueno, E. Barrera (IBUNAM). Paratypes: same data, 1 ♂ (USNM) and 1 ♂ (IBUNAM); Route Cuetzalan-Zacatlán, km 64, elevation 1,250 m, March 19 1987, J. Bueno, E. Barrera and H. Brailovsky 26 ♂ (IBUNAM).

Etymology.—*poblana:* A name given to the women born in Puebla, Mexico.



Figs. 42–43. *Ochrotrichia poblana,* male genitalia. 42, Left side. 43, Dorsal.

Ochrotrichia (O.) velascoi Bueno and Santiago, new species

(Figs. 44–45)

Because of the wide basal portion and narrow, elongate apical portion of the inferior appendages in lateral view, this species appears to be related to the Californian *Ochrotrichia buccata* Denning and Blickle. However, the shape and distribution of the spinelike processes of the tenth tergum will distinguish *Ochrotrichia velascoi* from *O. buccata* and others.

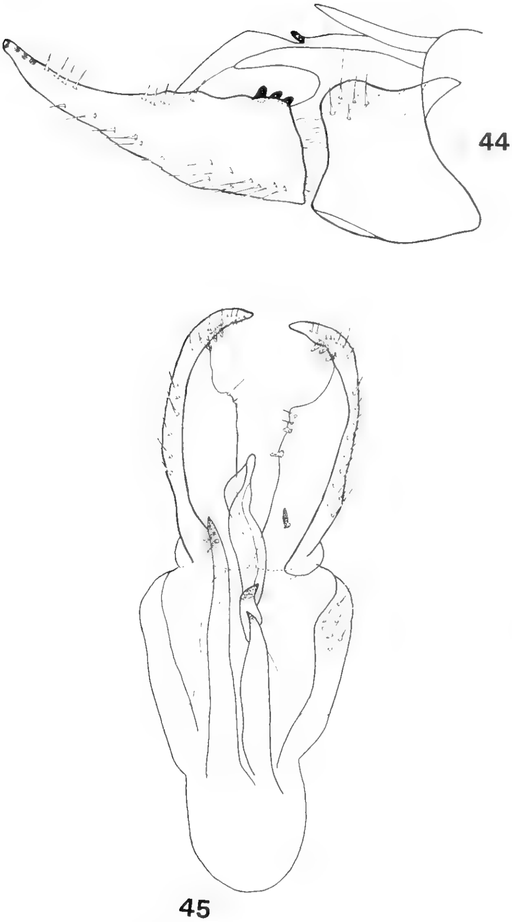
Adult.—Length of forewing, 2.5 mm. Color dark brown in alcohol. Male genitalia: ninth segment open dorsally and produced anteriad. Tenth tergum in dorsal aspect, with a short, middorsal, curved spine barely projecting beyond apex of a larger, dark-tipped spine; on right side with long, dark-tipped spinelike process; apical process wide, membranous, slightly sinuous and rounded at apex, arising from apex of shortest, middorsal, dark-tipped spine; in lateral aspect on right longest process appears wide basally and slightly curved ventrad, dorsalmost, dark-tipped spine shows only dark tip; apical process membranous, longer than other processes, and clearly curved ventrad. Inferior appendages in lateral aspect elongate, tapering to a pointed apex; three or more peglike seta near apex; in dorsal aspect, mesal face of left inferior appendage with a short, dark-tipped spine near base; apex of both appendages with three or more peglike setae. Phallus long and threadlike.

Material.—Holotype ♂: MEXICO: Guerrero, route 134, 102 km N. W. of Zihuatanejo, 1200 m, 7 June 1984, J. Bueno and E. Marino (IBUNAM). Paratype, same as holotype, 1 ♂ (USNM).

Etymology.—We dedicate this species to our student, Biol. Hector Velasco Madrigal.

ACKNOWLEDGMENTS

We are indebted to Dr. Oliver S. Flint Jr., Emeritus Curator of Neuropteroids of the Department of Entomology, National Museum of Natural History, Smithsonian In-



Figs. 44–45. *Ochrotrichia velascoi,* male genitalia. 44, Right side. 45, Dorsal.

stitution, for his comments on the manuscript; to Dr. P. J. Spangler for his invitation to work under a grant from the National Museum of Natural History, Smithsonian Institution; to Mrs. Phyllis Spangler for her help with the word processing of the manuscript; to Miss Nancy Adams, support staff of the National Museum of Natural History, Smithsonian Institution, for her assistance while we were working in the Museum; to M. en C. Enrique Marino for his help while collecting in the field; to Biol. Rafael Barba Alvarez, our technician, for his assistance in preparing the specimens from the collection of the UNAM; and finally to the anonymous reviewers for their time and effort to improve the manuscript.

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NOTE

Note on Stoneflies (Plecoptera), Particularly *Prostoia besametsa* (Ricker) (Nemouridae), in the Diet of Salmonids from the Headwaters of the Middle Fork of the South Platte River, Colorado

A previous report (Duffield and Nelson 1993. Aquatic Insects 15: 141–148) noted that profiles of salmonid diet can provide useful information about the relative abundance and the life history of the prey items consumed. An example of this approach was a recent investigation of stoneflies, particularly *Prostoia besametsa* (Ricker) (Nemouridae), in the diet of three Rocky Mountain salmonid species during a limited period of the year. *Prostoia besametsa* is an abundant species, often exhibiting high population densities in lowland creeks throughout its range (Baumann et al. 1977. Memoirs of the American Entomological Society 31: 1–208). A few studies have listed nemourid stoneflies in the diet of salmonids (Allan 1978. Verhandlungen der internationalen Vereinigung fur Limnologie 20: 2045–2050; McNicol et al. 1985. Environmental Biology of Fishes 12: 219–229; Hubert and Rhodes 1989. Hydrobiologia 178: 225–231; Duffield and Nelson 1993), but none reported this species.

The study area was upstream of the junction of Mosquito Creek and the Middle Fork of the South Platte River, north of Fairplay (Park County), Colorado (39°15′N, and 106°04′W). A total of 38 salmonids consisting of the brook trout (*Salvelinus fontinalis* Mitchell), brown trout (*Salmo trutta* L.) and cutthroat trout (*Oncorhynchus clarki* Richardson) were sampled on six separate days from May 29 through June 10, 1992. The fish were collected during the late morning and early afternoon using artificial dry flies. Stomach contents were collected with a pump (Duffield and Nelson 1993), placed into 4 dram vials and preserved with 70% ethanol. Each salmonid was measured and released unharmed.

Stoneflies in the samples were identified to species whenever possible. Some partially digested adults and immatures could be identified only to the family or genus. All other insects were identified to order. Material is maintained in the authors' collections.

The lengths of the three salmonid species sampled ranged from 160 mm to 290 mm. A total of 2192 specimens were recovered from 38 stomach samples, for an average of 58 insect specimens per sample. Stoneflies were the most abundant insect order in the diet (46% of recovered items, Table 1). All but one sample contained at least one stonefly, and one sample contained eleven stonefly species. Five families and eleven genera of stoneflies were identified (Table 2). All have been reported in this drainage (Ward and Kondratieff 1992. University Press of Colorado, Niwot. 191 pp.).

Duffield and Nelson (1993) found that stoneflies are important in the diet of brown trout and rainbow trout during winter and spring in a mid-Atlantic stream. They speculated that since many North American stonefly species undergo nymphal diapause in the summer and emerge from winter to early summer, they are readily available for

Table 1. Insect orders recovered from salmonid stomach samples taken from the Middle Fork of the South Platte River, Colorado.

Order	% of Total Specimens
Plecoptera	46.6
Diptera	22.3
Ephemeroptera	10.4
Trichoptera	9.4
Hemiptera	5.7
Hymenoptera	3.1
Coleoptera	0.8

Table 2. Plecoptera recovered from salmonid stomach samples taken from the Middle Fork of the South Platte River, Colorado.

Family Species	Nymph			Adult			
	Male	Female	Unknown	Male	Female	Exuvium	Total
Capniidae							
Capnia confusa	—	—	—	—	6	—	6
Nemouridae							
Prostoia besametsa	330	548	92	4	3	2	979
Zapada haysi	—	—	1	—	—	—	1
Chloroperlidae							
Suwallia sp.	—	—	12	—	—	—	12
Sweltsa sp.	—	—	7	—	—	—	7
Chloroperlidae sp.	—	—	1	—	—	—	1
Perlodidae							
Cultus aestivalis	—	—	3	—	—	—	3
Isoperla fulva	—	—	1	—	—	—	1
I. quinquepunctata	—	—	5	—	—	—	5
Kogotus modestus	—	—	2	—	—	—	2
Megarcys signata	—	2	1	—	—	—	3
Pteronarcyidae							
Pteronarcella badia	—	3	—	—	—	—	3
Total							1023

fish consumption only during this latter period of the year. This hypothesis is consistent with stoneflies being a dominant prey item of the Rocky Mountain salmonids examined in this study during late May and early June.

Approximately 96% of the stoneflies recovered were *Prostoia besametsa* (Nemouridae). The sample with the largest number of stonefly specimens contained 163 individuals, 161 of which were *P. besametsa.* Nearly all the individuals of *P. besametsa* recovered from the samples were late-instar nymphs (Table 2). Only a few adults were present in the samples even though they were abundant along the river margins and were frequently observed flying over the river. Radford and Hartland-Rowe (1971. Canadian Journal of Zoology 43: 1812–1817) reported a late April to July emergence for an Alberta population of *P. besametsa* and Hassage and Stewart (1990. Southwest Naturalist 35: 130–134) reported a late April to May emergence for a New Mexico population. It is possible that during the period of this study the late-instar nymphs of *P. besametsa* were intercepted by the salmonids in the water column or on the water surface as they were about to emerge. The female-biased sex ratio of 1M: 1.66F late-instar nymphs indicates, as has been reported for other stoneflies (Hynes 1976. Annual Review of Entomology 15: 25–42), that seasonal emergence of this species is protandrous with male emergence peaking slightly ahead of that of the females.

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NOTE

Cereal Leaf Beetle (Coleoptera: Chrysomelidae) as a Pest of Ornamental Grasses

The adventive cereal leaf beetle, *Oulema melanopus* (L.) (Coleoptera: Chrysomelidae), is distributed throughout Europe, extending into Siberia, northern Africa, and Scandinavia. It was first found in the United States in 1962 from Michigan. Since then, it has spread throughout the eastern United States. The cereal leaf beetle has been present in Maryland since 1967 (Haynes and Gage 1981. Annual Review of Entomology 26: 259–287). Since 1967, the cereal leaf beetle has been reported only feeding on small grains and corn.

The cereal leaf beetle is primarily a pest of small grains, *Avena sativa* L. (oats), *Hordeum vulgare* L. (barley), *Secale cereale* L. (rye), and *Triticum aestivum* L. (wheat), but summer adults may feed on *Zea mays* L. (corn). Reports in the European literature also list several genera of Poaceae as hosts—*Agropyron repens* (L.) Beauv. (quackgrass), *Avena fatua* L. (wild oat), *Brachypodium pinnatum* (L.) Beauv. (chalk false broom), *Dactylis glomerata* L. (orchardgrass), *Festuca gigantea* (L.) Vill., *H. murinum* L. (wall barley), *Lolium multiflorum* Lam. (annual ryegrass), *L. perenne* L. (perennial ryegrass), *Phalaris canariensis* L. (canarygrass), and *Phleum pratense* L. (timothy) (Hodson 1929. Bulletin of Entomological Research 20: 5–14; Balachowsky and Mesnil. 1953. Les Insectes Nuisibles aux Plantes Cultivees, pp. 788–795; Balachowsky. 1963. *In* Entomologie Appliqué à Agriculture, Vol. 2; Miczulski. 1973. Roczniki Nauk Rolniczych Seria E 3: 61–86; Schmitt. 1988. pp. 475–495 *In* Jolivet, P., E. Petitpierre, and T. H. Hsaio, eds., Biology of Chrysomelidae). Most of the United States literature on the cereal leaf beetle deals with small grains (Battenfield et al. 1982. Bulletin of the Entomological Society of America 28: 291–301). Wilson and Shade (1966. Annals of the Entomological Society of America 59: 170–173) tested the cereal leaf beetle on a number of grasses and found that it could feed and reproduce on *Triticum spelta* L. (spelt), *Phalaris arundineacea* L. (reed canarygrass), *Bromus inernis* Leyss. (smooth brome), *Elymus* sp. (wildrye), and *Festuca arundineacea* Schreb. (tall fescue). Castro et al. (1965. Quarterly Bulletin-Michigan State University Agricultural Experiment Station 47: 623–653) also found that the cereal leaf beetle could reproduce on *Setaria italica* (L.) Beauv. (foxtail millet).

On 9, 10, and 20 May 1996 I observed adults and second and third instar larvae of the cereal leaf beetle feeding on ornamental varieties of *Phalaris arundinacea* (ribbon grass) in three separate nurseries in Calvert and St. Mary's Counties Maryland. Also, cereal leaf beetle adults were found feeding on *P. arundinacea* in a landscaped garden in Anne Arundel County on 2 June. Two varieties of *P. arundinacea* were attacked—'Picta' and 'Strawberries and Cream'. Feeding damage by the beetle was typical cereal leaf beetle damage. Adjacent ornamental grasses in the genera *Chasmanthium* (sea oats), *Miscanthus,* and *Pennisetum* (fountain grass) were not being fed on.

Voucher specimens are deposited in the Maryland Department of Agriculture collection. Maryland Department of Agriculture Contribution Number CN 96-96.

C. L. Staines, *Maryland Department of Agriculture, Plant Protection Section, 50 Harry S. Truman Parkway, Annapolis, Maryland 21401, U.S.A.*

PROC. ENTOMOL. SOC. WASH.
99(2), 1997, pp. 377–378

NOTE

Collections of Stephanidae (Hymenoptera) in the Mid-Atlantic States Including an Eastern Record for *Schlettererius cinctipes* (Cresson)

The Nearctic Stephanidae includes two genera and six species as revised by Townes (1949. Proceedings of the United States National Museum 99: 361–370). They are parasitoids of wood-boring Coleoptera and Hymenoptera. Two species are native to eastern North America, *Megischus bicolor* (Westwood) and *Megischus brunneus* Cresson, but *M. brunneus* occurs only in southern Florida. Specimens of the family are not commonly collected. In 15 years of extensive Malaise trapping in Virginia, Maryland, and West Virginia, I have taken only 49 specimens. Of these, 42 were taken in one trap at the same spot over a two-year period in Essex Co., Virginia. All specimens were *M. bicolor,* except for one specimen of *Schlettererius cinctipes* (Cresson) taken in Fairfax Co., Virginia. *Schlettererius cinctipes* is native to the Pacific coast states, with one record from the Black Hills of South Dakota.

Megischus bicolor (Westwood)

This species occurs from Massachusetts and southern Ontario south to Florida and west to Iowa, Utah, Texas, southern Arizona and southern California. The host recorded is "buprestid in *Cercidium torreyanum* [a synonym of *Cercidium floridum* Benth. ex A. Gray]" (Carlson. 1979. Catalog of Hymenoptera in America North of Mexico, Vol. 1, pp. 740–741). Other rearing records are emerging from *Quercus, Q. bicolor* Willd., *Carya, Cercidium,* and *Pinus,* and specimens have been collected from dead *Populus grandidentata* Michx. and a standing, dead *Fagus grandifolia* Ehrh. (Townes 1949, Carlson 1979).

The flight of *Megischus bicolor* in Virginia is from the end of May into September, with most records in June (15), July (16), and August (13). These records were from traps at the edge of woods, mostly *Pinus* spp., *Quercus* spp., *Liquidambar styraciflua* L., and *Liriodendron tulipifera* L. The sex ratio for trapped specimens was 22 females and 26 males.

Collection records.—MARYLAND: Prince George's Co., Beltsville Agricultural Research Center, VII-20-28-93 (1 ♀). VIRGINIA: Essex Co., 1 mi SE Dunnsville, V.25–VI.5.91 (1 ♂), VI.15–27.91 (3 ♀), VI.28–VII.11.91 (1 ♀), VII.12–26.91 (1 ♀, 1 ♂), VII.27–VIII.9.91 (1 ♀, 1 ♂), VIII.10–26.91 (5 ♀, 3 ♂), VIII.27–IX.16.91 (1 ♂), VI.12–24.92 (1 ♀, 8 ♂), VI.25–VII.6.92 (3 ♀, 1 ♂), VII.7–17.92 (4 ♂), VII.18–31.92 (1 ♀, 3 ♂), VIII.1–14.92 (1 ♀, 2 ♂), VI.10–23.93 (1 ♀), VII.16–VIII.1.94 (1 ♂), IX.7–30.94 (1 ♀). Fairfax Co., nr. Annandale (backyard trap), VII.16–22.93 (1 ♀), VIII.14–20.96 (1 ♀).

Schlettererius cinctipes (Cresson)

This species is known from British Columbia, Washington, Oregon, California, Arizona, Idaho, and South Dakota (Black Hills). It has been reared from various conifers in the West, including *Abies concolor* (Gord. and Glend.) Lindl., *Picea engelmanni* Parry, *Pinus ponderosa* Dougl. ex Laws., and *Pseudotsuga menziesii* (Mirb.) Franco (Townes 1949, Carlson 1979), and is a parasitoid of *Sirex noctilio* (F.) (Siricidae) in Australia where it was imported from western United States (Taylor 1967. Journal of the Australian Entomological Society 6: 13–19; Kirk 1975. Pan-Pacific Entomologist 51: 57–61).

This is the first record from eastern United States. The specimen was from a trap set in the backyard of our house in suburban Virginia; a nearby woodpile consists mostly of cut pine and maple. I have run a trap at this spot since 1981.

Siricids are commonly transported by commerce in wood and occasionally emerge in building after the wood is used for construction. Although *Sirex noctilio* is not Nearctic and not in the native range of *Schlettererius cinctipes, S. cinctipes* could parasitize other Siricidae, and thus be transported in the same manner.

Collection record.—VIRGINIA: Fairfax Co., nr. Annandale (backyard trap), VIII.4-10.96 (1 ♀).

KEY TO SPECIES

The Nearctic species are keyed by Townes (1949). The following couplet will separate the two species collected in the mid-Atlantic states.

1. First gastral segment about 2.5× longer than broad (Townes 1949, fig. 1); female hindtarsus 5-segmented; apical half of first and entire second and third metasomal segments orange . . . . *Schlettererius cinctipes* (Cresson)
– First gastral segment about 4× longer than broad (Townes 1949, fig. 2); female hindtarsus 3-segmented; metasoma black . . . . *Megischus bicolor* (Westwood)

I thank Mr. and Mrs. John G. Kloke for allowing field work on their property in Essex Co., Virginia. The following kindly reviewed the manuscript: Steve L. Heydon, University of California, Davis and Karl V. Krombein, Smithsonian Institution, Washington, D.C.

David R. Smith, *Systematic Entomology Laboratory, PSI, Agricultural Research Service, % National Museum of Natural History, MRC 168, Washington, DC 20560, U.S.A.*

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99(2), 1997, p. 378

NOTE

Species Homonymy in *Belomicrus* Costa (Hymenoptera: Sphecidae: Crabroninae)

In 1994 two new species of the wasp genus *Belomicrus* Costa were described under the name *montanus. Belomicrus montanus* Kazenas and Antropov (1994. Zoologicheskiy Zhurnal 73: 68–77) was published in January, and *B. montanus* Bohart (1994. Journal of Hymenoptera Research 3: 207–226) appeared November 16. Thus, Bohart's species is a junior homonym. I propose the replacement name *Belomicrus boharti* for *B. montanus* Bohart. It is named after Richard M. Bohart, in recognition of his work on this difficult genus.

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99(2), 1997, pp. 379–398

OBITUARY

George C. Steyskal
1909–1996

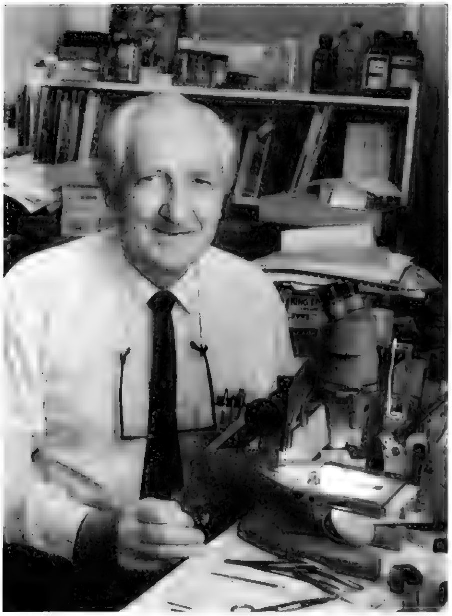
George Constance Steyskal, dipterist and former president of the Entomological Society of Washington, died in Gainesville, Florida on May 30, 1996. He had moved to Gainesville after the death of his wife in 1991. He is survived by a son, Neil Morgan Steyskal of Washington, D.C., and by two grandchildren, two great-grandchildren, and two brothers. A talented amateur with a publication record that few professional taxonomists would equal, tremendous knowledge of languages, and generous sharer of his expertise, his career merits recounting.

George was born in Detroit, Michigan, on March 30, 1909, the oldest of seven children. Early on, he entered factory work to help the family, graduating from the Henry Ford Trade School in Detroit. He worked for many years as a tool-and-die maker, finally becoming superintendent of a plant in that craft.

Although an amateur and employed in industry, his taxonomic papers, often accompanied by his own drawings, attracted attention. When a vacancy occurred in the U.S. Department of Agriculture's organization for taxonomic entomology, now known as the Systematic Entomology Laboratory (SEL), he applied and was appointed, at first as an Agricultural Research Technician, soon as Research Agriculturist. In spite of his publications and recommendations from prominent entomologists who knew him and his abilities, his lack of formal academic qualifications did not match the established requirements for Research Entomologist. However, his already excellent publication record won him appointment to a research position, for which he did full justice as his numerous publications attest. He was employed at SEL in Washington, D.C., from July 2, 1962 until his retirement on Sept. 30, 1979. He continued to work full time at SEL and the National Museum of Natural History, where he was a Research Associate, until after the death of his wife and his move to Florida, where he became a Resident Research Associate of the Florida State Collection of Arthropods.

George had broad interests in natural history, especially in insects, snails, and botany. His knowledge of plants, aided by his phenomenal memory, was wide ranging. Eventually he concentrated on Diptera and especially on the Acalyptratae, to which most of his published papers were directed. His assignment in SEL especially included plant-feeding Diptera of the families Tephritidae (fruit flies) and Agromyzidae (leaf miners), and here his knowledge of the plant hosts was especially valuable. No doubt many of his papers on varied subjects involved material that crossed his desk in SEL for identification, but the point is that he did something about it as well as about new material discovered in the National Collection at the Museum, and about linguistic or nomenclatural questions brought to him for advice.

The family Sciomyzidae was one of his early loves, and one of his best contributions. For years, North American species of the genus *Dictya* had been identified as *D. umbrarum* (Linnaeus), except for five species described by Curran in 1932. After describing a few species in 1938–1939, George studied the genus deliberately for some years, and in 1954 produced a definitive review of the genus with eight plates of figures of the male genitalia. By the time



George C. Steyskal at work (1977)

of the Nearctic Diptera Catalog (1965), George had described 13 of the 19 species then recognized in *Dictya.*

His publication record totals 446 titles (See Bibliography, based on his own list which often grouped the titles in catalogs). The breadth and size of his knowledge, interests, and contributions in Diptera are evident in the following figures:

4 new subfamilies in 4 different families;

24 new genera and 2 new subgenera in 10 families, mostly in his favorites: 9 in Sciomyzidae, 8 in Otitidae plus Platystomatidae;

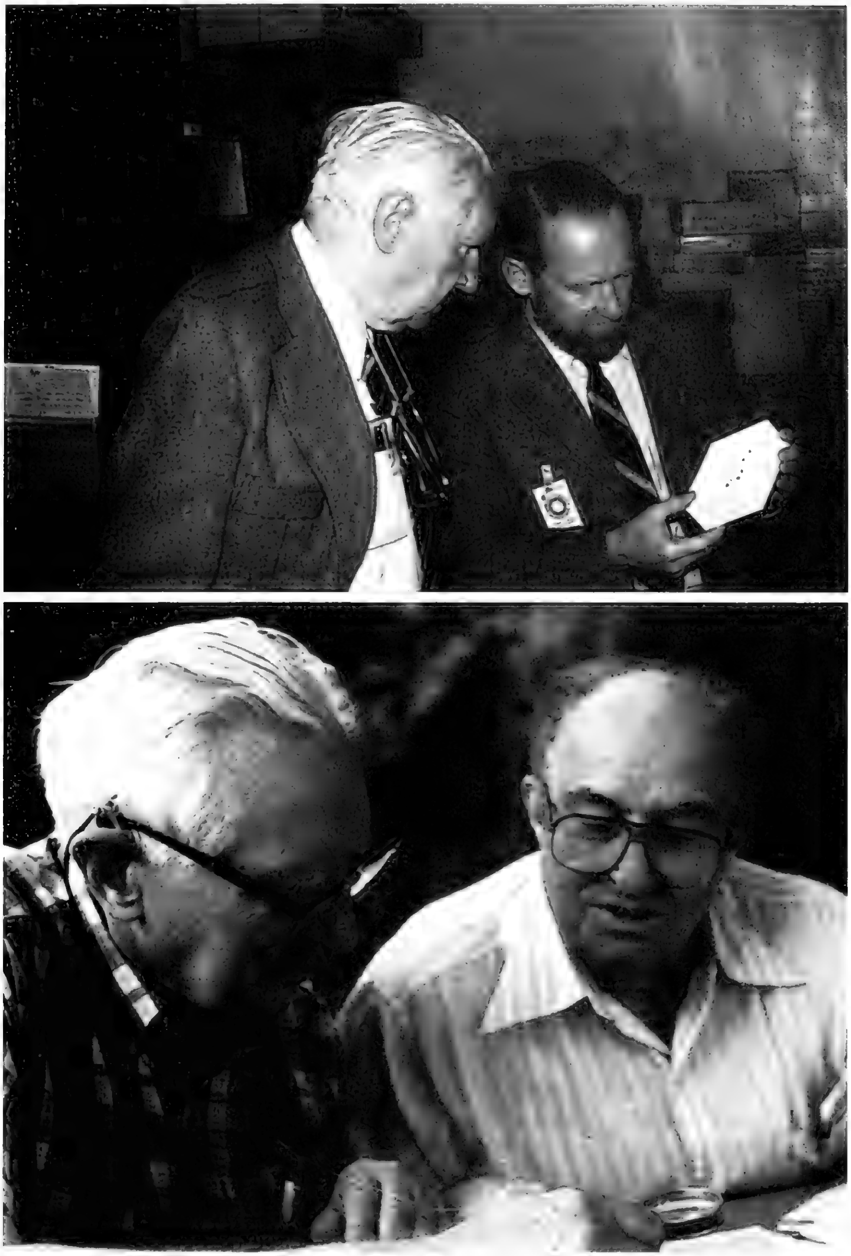
347 new species (including six *nomina nova* and eight subspecies) in 32 families (as presently recognized), chiefly in 22 of Acalyptratae, with scattered species in 10 other families, all species by Steyskal alone except for 34 co-authored with nine other persons. All this in addition to designations of type species and lectotypes, new synonymy, corrections of authorship or dates of publication, elevations in rank of family-group names, and a number of pertinent comments on applications in the *Bulletin of Zoological Nomenclature.*

George was a good cataloger, and he never failed to respond to requests for cooperation in the various regional catalogs. Thus he contributed 15 families for the Nearctic Catalog (1965); later 15 Neotropical, 16 Oriental, and 5 Afrotropical. In addition, he contributed chapters on 14 families (three co-authored) for the *Manual of Nearctic Diptera* (1981, 1987).

His cooperation, generosity, and ever-increasing publication record were also recognized by genera and species named in his honor. Four genera are based on his name: *Steyskalia* Aczél 1959 in Micropezidae, *Laksyetsa* Foote 1978 in Tephritidae, *Steyskaliella* Soós 1978 in Platystomatidae and *Steyskalomyza* Kurahashi 1982 in Dryomyzidae. Some 28 species have been named *steyskali,* but there is no up-to-date list of these. The published regional catalogs list ten such names but there are undoubtedly more in the years subsequent to the catalogs. As a further tribute, volume 3 of the Oriental Catalog (1977) was dedicated to George.

Another feature of his publication record is the number of book reviews, which often contained pertinent comments on the authors' treatments of scientific names. Oddly enough, in his personal list of publications he recorded the reviews but usually did not number them in his own total!

A remarkable facet of this amateur-become-professional was his lifelong interest in linguistics, both classical Latin and Greek and modern languages. He translated all (perhaps almost all!) the European languages and had studied others such as Arabic and Japanese. For recreation he read books in Italian. He was always helpful and generous with his time as colleagues visitors, and staff from around the Museum came to him for help with a phrase, a description, a type designation, or a translation from some foreign language. This made him a natural adviser on scientific names for the *Proceedings of the Biological*



George identifying flies, above with Keith Harris (on right) 1981, below with Sidney Camras (on the right) 1988.

Society of Washington and the *Proceedings of the Entomological Society of Washington,* which he served faithfully and promptly for over twenty years. Further, from 1980 until his death he was Translation Editor for Scripta Tecnica's *Entomological Review* (the Russian *Entomologicheskoe Obozrenie*). In the *Review* for June 1996, Scripta Tecnica published a fine tribute to his "untiring effort, his great linguistic skills, and his vast knowledge of entomology." During his years of service for the two Washington

George meeting with colleagues, above at the Montreal Congress (1956), Curtis Sabrosky, Reginald Painter, Frank Hull and George (left to right); below at the London Congress (1964), George, Jerry Rozen and Curtis Sabrosky (left to right).

journals, he was often able to correct errors in names before they appeared in print, or suggested names that better expressed the meanings intended by authors. I can testify personally to George's ability as a wordsmith in devising scientific names. In his own papers, one of his most brilliant proposals was for an anomalous genus of uncertain position whose exact place in Acalyptrate Diptera was long moot. His name: *Cinderella*!

His long interest in linguistics is evident in the number of titles dealing with scientific names and their correct spelling, gender, stem, and similar considerations. I counted at least 27 1945–1989, that clearly dealt with the grammar of names, besides some general papers and numerous items in regular taxonomic publications. As would be expected, most such papers concerned Diptera, but his wide-ranging interests, and no doubt in part the problems brought to him for advice, resulted in papers on names and their grammar in such varied groups as Amphibia, Arachnida, Coleoptera, Dermaptera, Heteroptera, Hymenoptera, Mallophaga, Plecoptera, and Psocoptera. His examples and recommendation have encouraged many authors to include a few lines on Etymology to show the derivation of their new scientific names.

George was an excellent collector and observer in the field, and his published papers from time to time reflected this, such as his notes on pre-copulatory and mating behavior in Dolichopodidae, color and color pattern in the eyes of live flies, and the dipterous fauna of tree trunks. As the years passed, there were fewer such papers and more on straight descriptive taxonomy.

His industry experience and natural talent were revealed many times in things he would construct, from a large and complete doll house for his granddaughter to a dropleaf table on which he and I dueled in a couple of games of rapid chess during our lunch breaks. He developed a method and equipment for making non-glass microvials for storing insect genitalia (see Gurney, Kramer & Steyskal 1964). He was always interested in matters of technique of all kinds, and wrote occasional papers on such subjects. Hence he was the logical lead author in an up-to-date revision of a large bulletin on "Techniques for Collection and Preservation of Insects and Mites" (see Steyskal, Murphy & Hoover 1986).

George was a loyal member of scientific societies, beginning with the local Detroit Entomological Society, which evolved in 1954 into the Michigan Entomological Society, of which he served as first President in 1955–56, and was voted Honorary Member in 1970. He joined the Entomological Society of Washington in 1947 (President in 1976) and the Entomological Society of America in 1949, continuing in both until his death. He was also a member, at least for some period of time, of other societies of which we know the Biological Society of Washington, Entomological Society of Canada, Florida Entomological Society, and the Society of Systematic Zoology.

Of his many interests, one that merits special mention is his love of and abiding devotion to classical music. He had a vast collection of records and great knowledge of them. He loved to sit quietly and listen to the music, sometimes singing in Italian along with the soloists.

Yes, George had faults, as who does not? Those in daily contact with him, in such matters as curation, protection of boxed specimens from insect pests, and reaction to manuscript committee's comments on his prose, were aware of some weaknesses, perhaps not unexpected in a chiefly self-taught individual without formal training or professorial guidance or oversight. With his brain power, what might have he accomplished with academic training!! Or would it have spoiled him? His colleagues recall with pleasure his remarkable memory, amazing knowledge of languages, breadth of interests, and the generous helpfulness of this multi-talented, self-taught amateur with a record of accomplishments that eclipses that of many professionals. As the publishers of

Entomological Review expressed it in a tribute to George in the June 1996 issue of the *Review,* his professional associates "will always remember his good humor, energy, zest for life and kindness, as well as his encyclopedic learning." He was truly an unusual individual. Having survived a quarter century of car-pooling with George, I can even chuckle over memories of his driving!

ACKNOWLEDGMENTS

I thank Jennifer Fairman for preparing the plates and Chris Thompson for preparing the list of publications. The list of publications was prepared from George's own list, but carefully checked against the originals. George's own annotated set of his papers is now held by the Systematic Entomology Laboratory, USDA. The photographs were taken by Chris Thompson (fig. 2) and George Byers (figs. 3–5). These photographs and most of George's scientific papers are now in the Smithsonian Archives. So, finally I thank William Cox of these Archives for his assistance.

Curtis W. Sabrosky, *205 Medford Leas, Meadford, NJ 08055–2236, U.S.A.*

SCIENTIFIC WRITINGS OF GEORGE C. STEYSKAL

1938

New Stratiomyidae and Tetanoceridae (Diptera) from North America. Occas. Pap. Mus. Zool. Univ. Mich. 386, 10 pp., 2 pls. [1938.10.29 imprint date, Steyskal marked it as received 1938.11.07]

1938

The pre-copulatory behavior of the male of *Dolichopus omnivagus* Van Duzee (Diptera, Dolichopidae). Bull. Brooklyn Ent. Soc. 33: 193–194. [1938. 11.15]

1938

Unusual pentatomid records. Bull. Brooklyn Ent. Soc. 33: 201. [1938.11.15]

1939

Notes on preparation technique. Bull. Brooklyn Ent. Soc. 33: 235. [1939.01.13]

1939

Ennearthron oblongum. Bull. Brooklyn Ent. Soc. 34: 20. [1939.02.27]

1939

A new species of *Dictya* (Sciomyzidae, Diptera). Canad. Ent. 71: 78. [1939.04.01]

1939

Distributional notes on Bembicidae (Hymenoptera). Bull. Brooklyn Ent. Soc. 34: 218–219. [1939.09.27]

1940

A list of Michigan Diptera. Bull. Brooklyn Ent. Soc. 35: 143. [1940.11.11]

1940

——— & C. W. Sabrosky. Diptera of Michigan. Ent. News 51: 242. [1940.11.08]

1940

Additional specimens of *Lasia purpurata* (Acroceridae). Bull. Brooklyn Ent. Soc. 35: 158. [1940.12.26]

1941

A curious habit of an Empidid fly. Bull. Brooklyn Ent. Soc. 36: 117. [1941.06.24]

1941

A new species of *Euparyphus* from Michigan (Diptera, Stratiomyidae). Bull. Brooklyn Ent. Soc. 36: 123–124. [1941.06.24]

1941

Odontomyia records (Diptera, Stratiomyidae). Bull. Brooklyn Ent. Soc. 36: 125. [1941.06.24]

1941

A new species of *Pterodontia* (Diptera, Acroceridae). Bull. Brooklyn Ent. Soc. 36: 140. [1941.06.24]

1942

A new species of *Phyllomyza* from Virginia (Diptera: Milichiidae). Ent. News 53: 84–85. [1942.03.20]

1942

Notes on the genus *Dolichopus* (Diptera, Dolichopodidae). Paper 2. Bull. Brooklyn Ent. Soc. 37: 62–67. [1942.06.30]

1942

A curious habit of an empidid fly; further notes. Bull. Brooklyn Ent. Soc. 37: 67 [1942.06.30]

1942

A note on preparing Diptera. Bull. Brooklyn Ent. Soc. 37: 69. [1942.06.30]

1942

Miscellaneous behavioristic observations upon Diptera (Clusiidae, Chloropidae, Sciomyzidae). Bull. Brooklyn Ent. Soc. 37: 101–102. [1942.08.27]

1943

Asterocampa celtis in Michigan (Lepidoptera: Nymphalidae). Ent. News 54: 27. [1943.02.06]

1943

A new species of *Pholeomyia,* with a key to the North American species (Diptera, Milichiidae). Ent. News 54: 99–102. [1943.04.27]

1943

Old World Sepsidae in North America, with a key to the American genera (Diptera). Pan-Pacific Ent. 19: 93–95. [1943.07.31]

1944

A new ant-attacking fly of the genus *Pseudacteon,* with a key to the females of North American species (Diptera, Phoridae). Occas. Pap. Mus. Zool. Univ. Mich. 489, 4 pp. [1944.12.11]

1945

Behavior of *Strauzia longipennis* var. *vittigera* Loew (Diptera, Trypetidae). Bull. Brooklyn Ent. Soc. 39: 156. [1945.02.20]

1945

The prey of *Crossocerus pammelas* Pate (Sphecidae). Bull. Brooklyn Ent. Soc. 39: 170. [1945.02.20]

1945

Note on preparing Diptera. Bull. Brooklyn Ent. Soc. 39: 170. [1945.02.20]

1945

A key to the North American species of the genus *Suillia* R.-D. (Diptera, Helomyzidae). Bull. Brooklyn Ent. Soc. 39: 173–176. [1945.02.20]

1945

Notes on *Nallachius americanus* (McL.) (Dilaridae, Neuroptera). Psyche 51: 183–184. [before 1945.02.25 receipt date at USNM]

1945

Nomenclature and semantics. Ent. News 56: 100–102. [1945.05.28 receipt date at USNM]

1945

[Anonymous] The butterflies of Wayne County, Michigan. The Detroit Entomological Society, Detroit, Michigan, [1945.06.??]

1945

Behavior of *Thaumatomyia* (=*Chloropisca*) species (Diptera, Chloropidae). Bull. Brooklyn Ent. Soc. 40: 48. [1945.06.13]

1945

Remarks upon spatial relationships in entomological description. Bull. Brooklyn Ent. Soc. 40: 57–59. [1945.06.13]

1945

Leafhoppers swarming (Homoptera, Cicadellidae). Bull. Brooklyn Ent. Soc. 40: 86. [1945.09.10]

1946

(Book Review) Foundations of Plant Geography, by Stanley Cain. Ent. News 57: 31. [1946.04.08]

1946

The number of species in a genus. Ent. News 57: 57–58. [1946.05.06]

1946

Themira nigricornis Meigen in North America, with a revised key to the nearctic species of *Themira* (Diptera: Sepsidae). Ent. News 57: 93–95. (1946.06.20]

1946

[Proposal and discussion of family name Ceroxydidae]. P. 170–171. *in* C. W. Sabrosky, Family names in the order Diptera. Proc. Ent. Soc. Wash. 48: 163–171. [1946.10.01]

1947

The genus *Diacrita* Gerstaecker (Diptera, Otitidae). Bull. Brooklyn Ent. Soc. 41: 149–154. [1947.01.30]

1947

The mating behavior of *Tachytrechus vorax*, *T. moechus*, and *Gymnopternus barbatulus* (Diptera, Dolichopodidae). Bull. Brooklyn Ent. Soc. 41: 168–169. [1947.01.30]

1947

Summa Brasiliensis Biologiae. Ent. News 58: 20. [1947.04.17]

1947

Notes on the genus *Dolichopus* (Diptera, Dolichopodidae). Paper 3. Bull. Brooklyn Ent. Soc. 42: 34–38. [1947.05.28]

1947

Distributional notes on Lauxaniidae mostly from the Great Smoky Mountains National Park (Diptera). Ent. News 58: 72–73. [1947.06.13]

1947

Micropezidae (Diptera) from the Solomon Islands. Occas. Pap. Mus. Zool. Univ. Mich. 502, 10 pp., 1 pl. [1947.08.04]

1947

The distribution by states of United States insect collection records. Ent. News 58: 154–156. [1947.09.30]

1947

A revision of the nearctic species of *Xylomyia* and *Solva* (Diptera, Erinnidae). Pap. Mich. Acad. Sci. Arts Letters 31: 181–190. [1947.10.??]

1947

Diostracus prasinus Loew in Tennessee (Diptera, Dolichopodidae). Bull. Brooklyn Ent. Soc. 42: 16. [1947.05.28]

1947

A new genus and species of Rhopalomeridae from northwestern Mexico (Diptera). Proc. Ent. Soc. Wash. 49: 225–228. [1947.11.12]

1949

New Diptera from Michigan (Stratiomyidae, Sarcophagidae, Sciomyzidae). Pap. Mich. Acad. Sci. Arts Letters 33: 173–180. [1949.05.02 separates received]

1949

Sarcophagidae (Diptera) from the Great Smoky Mountains National Park. Bull. Brooklyn Ent. Soc. 44: 60. [1949.04.29]

1949

Rhagionidae (Diptera) from the Great Smoky Mountains National Park. Bull. Brooklyn Ent. Soc. 44: 68. [1949.04.29]

1949

A new anomalous acalyptrate fly (Diptera). Bull. Brooklyn Ent. Soc. 44: 134–137. [1949.10.24]

1949

An indexing system for taxonomists. Coleopt. Bull. 3: 65–71. [1949.11.14 separates received]

1949

Sepsidae from the Australasian region (Diptera). Pan-Pacific Ent. 25: 161–171. [1949.11.25]

1949

Notes on color and pattern of eye in Diptera. Bull. Brooklyn Ent. Soc. 44: 163–164. [1949.12.13]

1950

The genus *Protodictya* Malloch (Diptera, Sciomyzidae). Proc. Ent. Soc. Wash. 52: 33–39. [1950.02.14]

1950

Notes and records of Phytalmiidae (Diptera: Acalyptratae). Wasmann J. Biol. 8: 93–96. [1950.05.17]

1950

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1950

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PROC. ENTOMOL. SOC. WASH.
99(2), 1997, pp. 399–401

BOOK REVIEW

Riceland Spiders of South and Southeast Asia. By A. T. Barrion and J. A. Litsinger. CAB International, Wallingford, Oxon, United Kingdom. 1995. 700 pp., 16 color plates Paperback. ISBN 0 85918 967 5. $225.00.

Perhaps one of the main differences between taxonomy and any other scientific discipline is the fact that in taxonomy, at least so far, bad work can live almost eternally. If one were to publish some truly absurd and erroneous scientific article, in almost any scientific discipline, the work would be immediately ignored by the scientific community and the contribution would quickly disappear into oblivion. *Requiescat in pace.* This is not true in taxonomy. One can describe and name new taxa in the worst possible way you can imagine, and as far as the publication criteria set forth by the International Code of Zoological Nomenclature are met, those names and descriptions will be "valid" ones and the scientific community will have to live with it. To a large extent quality may not matter; taxonomists cannot ignore a publication just because, let us say, the particulars of the description make any reliable identification virtually impossible. Subsequent generations of taxonomists will have to live with that name, no matter how bad (or good) the original description was, to the extent that a good fraction of their work will have to be devoted to correcting earlier mistakes. In this sense I predict that "Riceland spiders of South and Southeast Asia" (RSSSA) will be with us for a long, long time.

RSSSA treats more than three hundred species of spiders collected over a period of 13 years in rice ecosystems in the Philippines. Species collected in other five locations in South and Southeast Asia are also treated in this book. According to the abstract, the 342 species covered represent 131 genera and 26 spider families. A large fraction of the species treated (257 species or 75%) are reported as "new species." In addition, eight new genera are described, seven of them are monotypic.

The book is divided in thirteen sections. In the first two sections, Barrion and Litsinger offer a historical background of araneology in the Philippines and introduce the basics of spider external anatomy. The following four sections treat life history (it actually deals almost exclusively with eggsacs and first instars), materials and methods, and the classification and key to the spider families (in reality it only covers the spider families that have been found in rice ecosystems in South and Southeast Asia). The bulk of the book, more than 600 pages, is in the seventh section which is concerned with the description of all the taxa. The next four sections provide a brief description of some other arachnid orders, some comments on the diversity of spiders in Philippine rice ecosystems, the distribution maps of riceland spiders, and a glossary of arachnological terms. The book ends with the bibliography section and a species index. The book is profusely illustrated with aesthetically pleasing pen and ink drawings by Danilo Amalin and a few color photographs.

Dalingwater (1996. Newsletter of the British arachnological Society. 76: 6–7) has made extensive comments on the poor editorial quality of this book. I will not address those aspects here but instead will focus on the quality of the taxonomic work of RSSSA.

Barrion and Litsinger have succeeded in providing us with a real compendium. A compendium of what not to do in taxonomy. I will comment here on only a few of these points. For example, I have not found a single reference to examination of type specimens, except those of the new taxa described in this book (incidentally, Barrion and Litsinger do not tell us where the types of the 257 presumably new species they have described are deposited). Is it possible to discover so many "new taxa" without consulting the types of the many species that have already been described in that part of the world? I do not think so, precisely for the reasons I have brought up in the first paragraph. Barrion and Litsinger describe eight new genera (seven of them are monotypic) but in most cases these genera are known from only one or two specimens. Since this is not a revision of any of the groups treated I do not see any compelling reasons for describing a new genus from a single female specimen (e.g. *Gambaquezonia*). In fact, I can think of numerous reasons for not doing so. The lack of diagnosis for many of these new genera (e.g. *Kakaibanoides* or *Landopo*) adds another problem to it. Some of the family names and higher level delimitations used in the book are out of date. For example, Nephilinae is no longer an araneid subfamily, but a tetragnathid subfamily. *Comaroma* is not a theridiid, but a member of the Anapidae. New species are frequently described without a diagnosis and in many cases are based on a single specimen. At least one of the species names (the oonopid *Oopaea batangueña*) is an incorrect original spelling (Article 27 of the ICZN explicitly forbids the use of diacritic marks in scientific names) and will have to be corrected. The theridiid *Theridion kambalum,* known only from the female holotype, is described, presumably for the first time, without providing an illustration of the epigynum.

The authors state in the Introduction that the goal of their book is to provide a guide that can be used by specialists and novices to identify Philippine spiders. This is a very laudable goal, but I wonder about the need of describing so many new taxa in a book that is intended mainly as an identification guide. The book is based on spider collections in rice fields that span for more than 12 years, but, despite their efforts, the majority of the new species treated in the book are known from only one or a very few specimens (perhaps because they are not common in rice ecosystems). Given the title of the book, it may have been then advisable to treat only those species that are commonly found in rice fields. This would certainly make the task of identifying spiders form rice fields easier for some potential users of such a guide, like IPM specialists or agricultural entomologists.

I cannot evaluate in detail the taxonomy of all the families treated in this book, but I would like to address the quality of the taxonomic work of Barrion and Litsinger by making a few remarks on the Tetragnathidae. Judging from their original description, the spider they describe as *Phonognatha guanga* n. sp. is not a *Phonognatha,* not even a tetragnathid, but a linyphiid of the genus *Neriene. Meta baywanga* and *M. tiniktirika* are also misplaced since they also are linyphiids (possibly species of *Neriene*), not tetragnathids. All these taxa are treated under the family Metidae, a grouping abandoned by most taxonomists over the last decade. The Nephilinae have also been recognized as a group within Tetragnathidae for more than a decade, but we see them treated here as araneids. Of the six different species of *Nephila* that the authors claim that exist in the neotropics, only two, *Nephila clavipes* and *N. sexpunctata,* were recognized by Levi and von Eickstedt in their revision of 1989. These examples are not minor taxonomic changes hidden in obscure publications, but widely accepted changes that can be easily found, for example, in Platnick's spider taxonomy catalogs (N. I. Platnick 1989. Advances in Spider Taxonomy 1981–1987, Manchester University Press; 1993. Advances in Spider Taxonomy 1988–1991, New York Entomological Society and The American Museum of Natural History). What transpires from the treatment of Tetragnathidae is a number of errors that are too large to ignore: inadequate coverage of the taxonomic literature, gross misplacement of species in higher taxonomic categories, genitalic illustrations not detailed enough to allow accurate identifications, no allusion to examination of type material, lack of diagnosis in descriptions of new taxa, no evidence of peer review, etc.

It is obvious that much time, resources, and dedication went into the production of RSSSA. I have no doubts that the authors tried to accomplish their job as best as they could, but the final product certainly leaves much to be desired. This book also leaves many open questions. Was this manuscript ever reviewed by specialists before it was accepted for publication? If not, what kind of scientific policies at the agency responsible for the publication of RSSSA allow something like this to happen? Could this happen again? Could RSSSA have been better produced as a true identification guide for a wider audience, not as an attempt to deal with the taxonomy of Philippine spiders?

The high price alone will keep this book mainly confined to institutional libraries. Based on the quality of the product it is difficult to recommend the purchase of RSSSA, but then again, quality is not a guiding criterion for the taxonomists when it comes to use the available literature. Systematists working with the spider fauna of southern Asia will have to use this reference given the enormous, quantitatively speaking, nomenclatural weight of the book.

I would like to thank Jonathan Coddington for his comments on a draft of this review.

Gustavo Hormiga, *Department of Biological Sciences, George Washington University, Washington, D.C., 20052 and Department of Entomology, NHB -105, Smithsonian Institution, Washington, D.C., 20560.*

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REPORTS OF OFFICERS

EDITOR

Volume 98 of the *Proceedings* totaled 844 pages. Eighty-one articles, eight notes, three book reviews, one obituary, the Bylaws of the Society, membership list of the Society, and instructions for authors were published.

In addition, Memoir 17 "Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein" edited by B. B. Norden and A. S. Menke was published in 1996. Memoir 18, "Contributions to Diptera," a volume in memory of W. W. Wirth, edited by W. N. Mathis and W. L. Grogan, will be published in December. Memoir 19, "Monograph of the Berytidae, or Stilt Bugs (Heteroptera) of the Western Hemisphere" by T. J. Henry, was approved by the Executive Committee and will appear in 1997. Approval was also given by the Executive Committee to print a second edition of "A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera)," by E. E. Grissell and M. E. Schauff; this will appear in 1997.

I extend my appreciation to Gary L. Miller for his continuing efforts to acquire informative book reviews, to Tom Henry and Wayne Mathis for their work on memoirs and kindly offering advice, and to Marie Blair for her assistance in handling correspondence and routing manuscripts. Without their help, my job would have been much more difficult.

I am also grateful to the many reviewers for their time-consuming efforts and constructive reviews. Their contributions are essential to help increase the quality of papers published in the *Proceedings.*

David R. Smith, *Editor*

PRESIDENT-ELECT

The 1996 Annual Banquet was held on 15 May 1996 at the Associates Court of the National Museum of Natural History in Washington, D.C. 93 tickets were sold (12 to students). Members and guests of the Entomological Society of Washington were joined by members of the Maryland Entomological Society. The Master of Ceremonies for the evening was Dr. David Furth. The speaker was Dr. May Berenbaum of the University of Illinois at Champagne-Urbana who spoke on "Images of the Entomologist—Moving or Otherwise."

Receipts from the sale of tickets were $1914.00, however the actual cost of the event was $1997.45 (DAKA) and 372.75 (SI Audio-Visuals) for a total of $2370.20. The difference of $456.20 was subsidized by the society and included complimentary dinner for the speaker and the Master of Ceremonies. In addition, the Executive Committee authorized a $500.00 honorarium for the speaker. Dr. Ray Gagné was the most outstanding ticket salesperson selling 50 tickets.

M. Alma Solis, *President-Elect*

SUMMARY FINANCIAL STATEMENT FOR 1996

	General Fund	Special Publications Fund	Total Assets
Assets: November 1, 1995	$ 1,145.72	$109,977.60	$111,123.32
Total Receipts for 1996	77,817.38	21,301.17	99,118.55
Total Disbursements for 1996	70,065.45−	23,678.92−	93,744.37
Assets: October 31, 1996	8,897.65	107,678.92	116,497.50
Net Changes in Funds	$ 7,751.93	$ (2,377.75)	$ 5,374.18

Audited by the Auditing Committee, December 3, 1996, consisting of Norman E. Woodley, Thomas J. Henry, and F. Christian Thompson, Chairman. Presented to the membership at the meeting of December 5, 1996.

Respectfully submitted,
Michael G. Pogue, *Treasurer*

SOCIETY MEETINGS

1013th Regular Meeting—October 3, 1996

The 1013th Regular Meeting was called to order at 8:01 pm by President Ralph Eckerlin on 3 October 1996 in the Waldo Schmitt Room, National Museum of Natural History, Washington, D.C. Nine members and six guests were present. The minutes of the May 2 and May 15 meetings were read by Acting Recording Secretary Gabriela Chavarria, and approved as read.

President Eckerlin called for office reports. David Smith made comments on the status of the Memoirs.

Program Chair David Furth announced that the speaker for the November Regular Meeting would be Christopher Marshall from the Department of Entomology, Cornell University.

President Eckerlin received a letter from the Washington Academy of Sciences, affiliated with the National Academy of Sciences; Chris Thompson is our representative or delegate to the Washington Academy of Sciences and they will keep us informed of upcoming events.

No new membership applications were received.

Ralph Eckerlin called for any Old or New Business. There was none and he requested that anyone with notes or exhibitions come forward. Ed Saugstad brought a newspaper with some humorous insect news. President Eckerlin brought a monograph of the World Bank who has committed 80 million dollars for integrative pest management.

Dr. Thomas K. Wood was the speaker for the evening. He is a professor at the Department of Entomology and Applied Ecology, University of Delaware. His presentation was entitled "Speciation of *Enchenopa* Treehoppers: Past and Future Studies." He kindly submitted the following abstract for publication in the Society minutes:

> Evidence for a particular hypothesis of speciation is most often inferential and rarely amenable to direct experimental tests. He discussed the establishment and the initial results associated with a long-term experimental test of a hypothesized speciation mechanism. The hypothesis tested was that shifts or changes in host plant use can initiate a process that leads to specialization and divergence. Specifically, the experiment was designed to examine the initial events associated with specialization through host shifts when gene flow is not precluded. For experimental purposes he selected a member of the *Enchenopa binotata* species complex (Homoptera: Membracidae) associated with the host plant *Viburnum*.
>
> To simulate two alternative modes of host specialization, seven environments using large walk-in outdoor cages were created, and replicated four times. Each cage contains two large plants at opposite ends, separated by approximately 8.0 m. Different combinations of the host plants in the genus *Viburnum* were tried. The first four represent allopatric environments, while the remaining three represent sympatric environments, where gene flow among insects associated with each host species is not precluded.
>
> Female treehoppers were painted and then released on each plant in the seven environments. Oviposition was monitored. Deposition of over 12,000 egg masses was directly observed during the first year. Since the release plant for each female within cage is known, the tendency of females to disperse from their release plant can be determined, and gene flow of insects between plants in the first generation of a host shift can be estimated. The timing of egg hatch, survival, development time, eclosion, and gene flow during mating and oviposition were determined. These results showed the role of host fidelity or philopatry in the initial stages of a host shift.

Six visitors were introduced. Lin Chung-Ping, Michael Adams and Ding Liu from the University of Delaware, Astrid Caldas, Research Associate in Entomology, and Alejandro Lopera from Colombia working with Dr. Adrian Forsyth, Research Associate in Entomology.

The meeting was adjourned at 9:16 pm. Refreshments were kindly provided by Ralph Eckerlin.

Respectfully submitted,

Gabriela Chavarria for Darlene Judd,
Recording Secretary

1014th Regular Meeting—November 7, 1996

The 1014th Regular Meeting was called to order at 8:04 pm by President Ralph Eckerlin on 7 November 1996 in the Waldo Schmitt Room, National Museum of Natural History, Washington, D.C. Sixteen members and 14 guests were present. The minutes of the October 3rd meeting were read by Acting Recording Secretary Dawn Southard, and approved as read.

President Eckerlin called for officer reports. Alma Solis gave the report of the President-Elect which provided details of the 1996 Annual Banquet.

Three new member applications were received and their names read: Charles L. Brockhouse, Fernando Munoz-Quesada, and Steve W. Chordes III.

David Smith reported that the Bylaws of the Society were published in the July issue and he provided copies for anyone interested along with copies of the Instructions for Authors.

Program Chair David Furth announced that the speaker for the December Regular Meeting would be Astrid Caldas, a Research Associate from the Department of Entomology, National Museum of Natural History, who will be speaking on the ecology and evolution of dead leaf butterflies.

The Slate of Officers for 1997 was read by the Chair of the Nomination Committee, Wayne Mathis, who also expressed thanks to the officers of last year for their outstanding performance. The Slate of Officers which will be voted on during the December 5th Regular Meeting include: M. Alma Solis, President; Warren E. Steiner, President-Elect; Harold Harlan, Recording Secretary; Hollis B. Williams, Corresponding Secretary; Gary L. Miller, Custodian; Michael G. Pogue, Treasurer; David G. Furth, Program Chair; David Adamski, Membership Chair; David R. Smith, Editor; and Ralph P. Eckerlin, Past President. The other members of the nominating committee, Thomas J. Henry and F. Christian Thompson, were thanked for their participation.

Wayne Mathis also announced that Memoir 18 in honor of Willis W. Wirth is due this year and is awaiting the second page proof from Allen Press. It was suggested that David Furth could use some money to supplement honoraria or other expenses.

Ralph Eckerlin reported that during the Executive Committee Meeting issues that needed to be addressed were the allotment of space for back issues, and monetary concerns.

Ralph Eckerlin asked if there were any new members and none were present. He called for any Old or New Business. There was none and he requested that anyone with notes or exhibitions come forward. Warren E. Steiner remarked on the passing of Ted Spilman on the 22nd of September, 1996, and that there is a committee being formed to prepare his obituary. Ted Spilman was the main historian for the Society over the last several years, and he presented a history of the Society at the 1000th Meeting of the Society. Ted Spilman served as former Treasurer and President of the Society. Ralph Eckerlin requested a moment of silence in his memory. Ed Saugstad brought a sample of entomological T-shirts for display, and Joyce Utmar also had one for display. David Furth presented a joke aimed at molecular systematists.

Joyce Utmar, a life member of the Society, presented a poem entitled "Beetles" written by Ted Spilman. She also presented her "specimen," Mark Grant, that she reported represented a new genus and species, *Grantius marcus*.

David Furth introduced the speaker for the evening, Chris Marshall, who is a graduate student at Cornell University in the Department of Entomology. His presentation was entitled, "Passalidae from A to Z: The Biology and Systematics of the Social Beetle Family." The aim of his talk was to serve as an introduction to the remarkable scarabaeoid family, Passalidae. First, the characteristics of all passalids as well as their phylogenetic position among other scarab families was discussed. He presented various results from studies based on morphology, life history, social behavior, and communication. The role of passalids in ecological systems as decomposers and creator of microhabitats by way of their galleries was discussed. This talk stressed the critical role of phylogenetic research both in general and specifically with reference to passalid biology. Examples of the utility of phylogenetic information in passalid biology, such as biogeography, conservation, adaptation and coevolutionary processes, were presented. He concluded his talk by discussing his current research on the genus *Verres* (tribe: Proculini) and his plans to answer questions related to brachyptery and coevolution between these beetles and the mites found associated with them. Upon conclusion of his talk, Chris Marshall passed around live specimens of passalids from Georgia.

Four visitors were introduced: Wenhua Lu from Rhode Island, working on mordelid beetles; Jean-Michel Maes, Museo Entomologia, Nicaragua; Diomedes Quintero, University of Panama, working on scorpions and mutilids; and Dr. Volker-Hollmann-Schirrmacher, arranging for a Postdoctoral Fellowship in the Department of Entomology which will begin in January.

The meeting was adjourned at 9:38 pm. Refreshments were kindly provided by David Furth and Gabriella Chavarria.

Respectfully submitted,
Dawn Southard for Darlene Judd,
Recording Secretary

1015th Regular Meeting—December 5, 1996

The 1015th Regular Meeting was called to order at 8:04 pm by President Ralph Eckerlin on 5 December 1996 in the Waldo Schmitt Room, National Museum of Natural History, Washington D.C. Thirteen members and 11 guests were present. The minutes of the November 7th meeting were read by Acting Recording Secretary Dawn Southard. A correction to the minutes was made by Wayne Mathis. This correction stated that Norman E. Woodley was a member of the nominating committee not F. Christian Thompson. The records were later checked and indeed the minutes were correct as read and F. Christian Thompson was on the nominating committee not Norman E. Woodley.

President Eckerlin called for office reports. Dawn Southard read the report of the Membership Chairman (David Adamski). President Ralph Eckerlin read the Corresponding Secretary's Report (Hollis B. Williams). The Treasurer's Report was read by M. Alma Solis and the Editor's Report was read by David Smith.

The outgoing President Ralph Eckerlin gave thanks to his executive committee members which include the Recording and Corresponding Secretaries, the Editor and his aids, the Treasurer, and the Program Chair. President Eckerlin pointed out that these are the hardest working members and whom the Society's survival has depended on. The President also expressed having enjoyed his tenure serving as the Society's President.

President Eckerlin turned the attention of the meeting to the Election of New Officers. The Chair of the Nominations Committee, Wayne Mathis, read the Slate of Officers and noted that two of the Officers are not voted on, that of the current President-Elect and the Past President. The Slate of

Officers include: M. Alma Solis, the President-Elect now becomes the President in accordance with the Bylaws; Warren E. Steiner, Jr., President-Elect; Harold Harlan, Recording Secretary; Hollis B. Williams, Corresponding Secretary; Gary L. Miller, Custodian; Michael G. Pogue, Treasurer; David G. Furth, Program Chair; David Adamski, Membership Chair; David R. Smith, Editor; and Ralph Eckerlin, Past President. President Ralph Eckerlin opened the floor for any further nominations; none were offered. Wayne Mathis responded that we should have a vote of the membership on the Slate of Officers. All present were in favor and there was no opposition.

President Eckerlin asked if there was any Old or New Business. M. Alma Solis inquired about the possibility of changing the date of the January meeting to the 9th because so many people would be away due to the holidays. Program Chair David Furth responded that the speaker was flexible and could be here for either the 2nd or the 9th of January. The President put the matter on the floor for a vote. Twenty two people voted in favor to change the date to the 9th and two opposed. The January meeting will be scheduled for the 9th.

President Eckerlin requested that anyone with notes or exhibits come forward. David Furth brought the newly published 3 volume set on Chrysomelid Biology which is on the market for $450.00.

David Furth announced that the speaker for the January meeting would be Charles Bellamy, a curator of Coleoptera at the Transvaal Museum in South Africa. The proposed title of the talk is "Beetle Collecting in Southern Africa (An Inordinate Fondness: Habitats, and Habitus)." David Furth introduced our speaker for the evening, Astrid Caldas, originally from Brazil, and now here in the Department of Entomology. The presentation, entitled "A Lively View of Dead-Leaf Butterflies," was about the population structure, mortality factors, and levels of mortality in immatures of the neotropical dead-leaf butterfly *Anaea ryphea*. The talk also looked at the intraspecific variation in *Anaea ryphea* adults and in a related species, *Anaea eurypyle*, and the possible taxonomic implications.

Four visitors were introduced: Pamela Burns, USDA-APHIS out of Gulfport, Mississippi; Manual Balcazar working on his Ph.D. at the University of Florida in Gainesville; Luis Jolly from the Universidad de Venezuela; and Cathy Anderson, museum technician with the Systematic Entomology Laboratory.

Past President Ralph Eckerlin presented the gavel to President M. Alma Solis who wished everyone a Happy Holiday, and the meeting was adjourned at 9:18 pm. Refreshments were kindly provided by Ralph Eckerlin.

Respectfully Submitted,
Dawn Southard for Darlene Judd,
Recording Secretary

Recent and Upcoming Publications of the Entomological Society of Washington

Memoir No. 17
Contributions on Hymenoptera and Associated Insects,
Dedicated to Karl V. Krombein. Edited by B. B. Norden and A. S. Menke.
216 pp. 1996 (cost: $25.00).

A Festschrift in recognition of Dr. Karl V. Krombein, Smithsonian Institution, Washington, D.C. A collection of 22 invited papers, mostly on Hymenoptera, from Dr. Krombein's colleagues around the world. Biographic highlights and a bibliography of Dr. Krombein's publications by Beth B. Norden are presented.

Memoir No. 18
Contributions on Diptera, Dedicated to Willis W. Wirth.
Edited by Wayne N. Mathis and William L. Grogan, Jr.
297 pp. 1997 (cost: $25.00).

A memorial volume dedicated to D. Willis W. Wirth, eminent Dipterist and long-time employee of the Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D.C. A collection of invited papers, mostly on Diptera, prepared by Dr. Wirth's colleagues around the world.

Memoir No. 19
Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the
Western Hemisphere. By Thomas J. Henry. To be published in 1997.

Western Hemisphere Berytidae include 3 subfamilies, 13 genera, and 53 species. Keys and numerous illustrations are provided for identification, and information on host plants, feeding habits, and economic importance are provided. An important, comprehensive work on this family.

Miscellaneous Publication
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera)
Second Edition, Revised.
By E. Eric Grissell and Michael E. Schauff. To be published in 1997.

This is a revised edition of the 1990 handbook on chalcids by the same authors. The content is updated with the numerous advances that have appeared since 1990. Pictorial keys and discussions of the characteristics, biology, distribution, and literature of each family as well as collecting and mounting techniques and morphology make this a most useful introduction and overview of the superfamily.

PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

MISCELLANEOUS PUBLICATIONS

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00

MEMOIRS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

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No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
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No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
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No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00

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PUBLISHED QUARTERLY

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OF WASHINGTON

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TRIOZA CHENOPODII REUTER: FIRST NORTH AMERICAN RECORD OF AN OLD WORLD PSYLLID (HOMOPTERA: PSYLLOIDEA: TRIOZIDAE)

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(AGW) Department of Entomology, Clemson University, Clemson, SC 29634, U.S.A.; (ERH) Department of Entomology, Cornell University, Ithaca, NY 14853, U.S.A.

Abstract.—Collection of the psyllid *Trioza chenopodii* Reuter (Triozidae) at Charlottetown, Prince Edward Island, Canada, in July 1995, represents the first record of this common Palearctic species in North America. Adults were collected on *Atriplex littoralis* L. (Chenopodiaceae). A summary of this psyllid's Old World distribution, the biological literature, and a taxonomic diagnosis and description are provided.

Key Words: Homoptera, Psylloidea, *Trioza chenopodii,* Triozidae, detection, adventive insects, Chenopodiaceae, *Atriplex*

Our work on adventive insects in eastern North America has emphasized their detection in areas especially vulnerable to invasion and establishment by Old World species, documentation of their spread, and observations on their seasonality and habits. Since 1993, we have collected in the Maritime Provinces of Canada, which historically have provided numerous records of immigrant insects (e.g., Brown 1940, Morris 1983, Hoebeke and Wheeler 1996). Nova Scotia, in particular, continues to yield species new to the Nearctic Region (see Hoebeke and Wheeler 1996). Herein we report the first North American collection of the psyllid *Trioza chenopodii* Reuter (Triozidae); summarize the Old World literature on its distribution, life history, and habits; and provide a diagnosis and description to facilitate its recognition among other psyllids in the Nearctic fauna.

TAXONOMIC HISTORY

Trioza chenopodii is a polymorphic species that occurs in both a longwinged summer form (*aestivalis*) and a shortwinged autumn and winter form (*autumnalis*). These forms, long considered separate species, were established through laboratory rearing to represent dimorphic forms of a single species (Lauterer 1982). Originally described in *Trioza* Förster (Reuter 1876), *chenopodii* was placed in the subgenus *Heterotrioza* (Dobreanu and Manolache 1962), which was raised to generic level by Klimaszewski (1968). In that taxonomic scheme, *chenopodii* belongs to the nominate subgenus *Heterotrioza* (Klimaszewski 1973). Here, however, we follow Hodkinson and White (1979) and Ossiannilsson (1992) in retaining this species in *Trioza.*

DIAGNOSIS AND DESCRIPTION

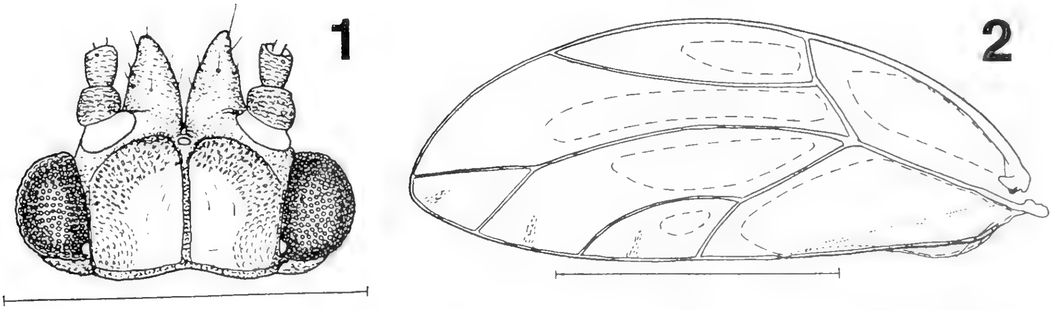
Trioza chenopodii Reuter
(synonymy: after Lauterer, 1982:148;
Ossiannilsson, 1992:324)

Trioza chenopodii Reuter, 1876:76 (= form *autumnalis*).

Trioza obliqua Thomson, 1877:825 (= form *aestivalis*).

Trioza dalei Scott, 1877:31 (= f. *autumnalis*).

Trioza atriplicis Lichtenstein, 1879:cxv (= f. *aestivalis* and ? partly f. *autumnalis*).



Figs. 1–2. *Trioza chenopodii,* male (f. *aestivalis*). 1, Head, frontal aspect. 2, Forewing. Scale line for Fig. 1 = 0.5 mm and for Fig. 2 = 1.0 mm. (From Ossiannilsson, 1992: 323).

Trioza galii; Jacobsen, 1919:359, nec Förster, 1848:87 (form indeterminate).
Trioza horvathi; Jacobsen, 1919:360, nec Löw, 1881:263 (= f. *aestivalis*).
Trioza (*Heterotrioza*) *chenopodii*; Klimaszewski, 1973:241.
Heterotrioza chenopodii; Lauterer, 1982: 148.

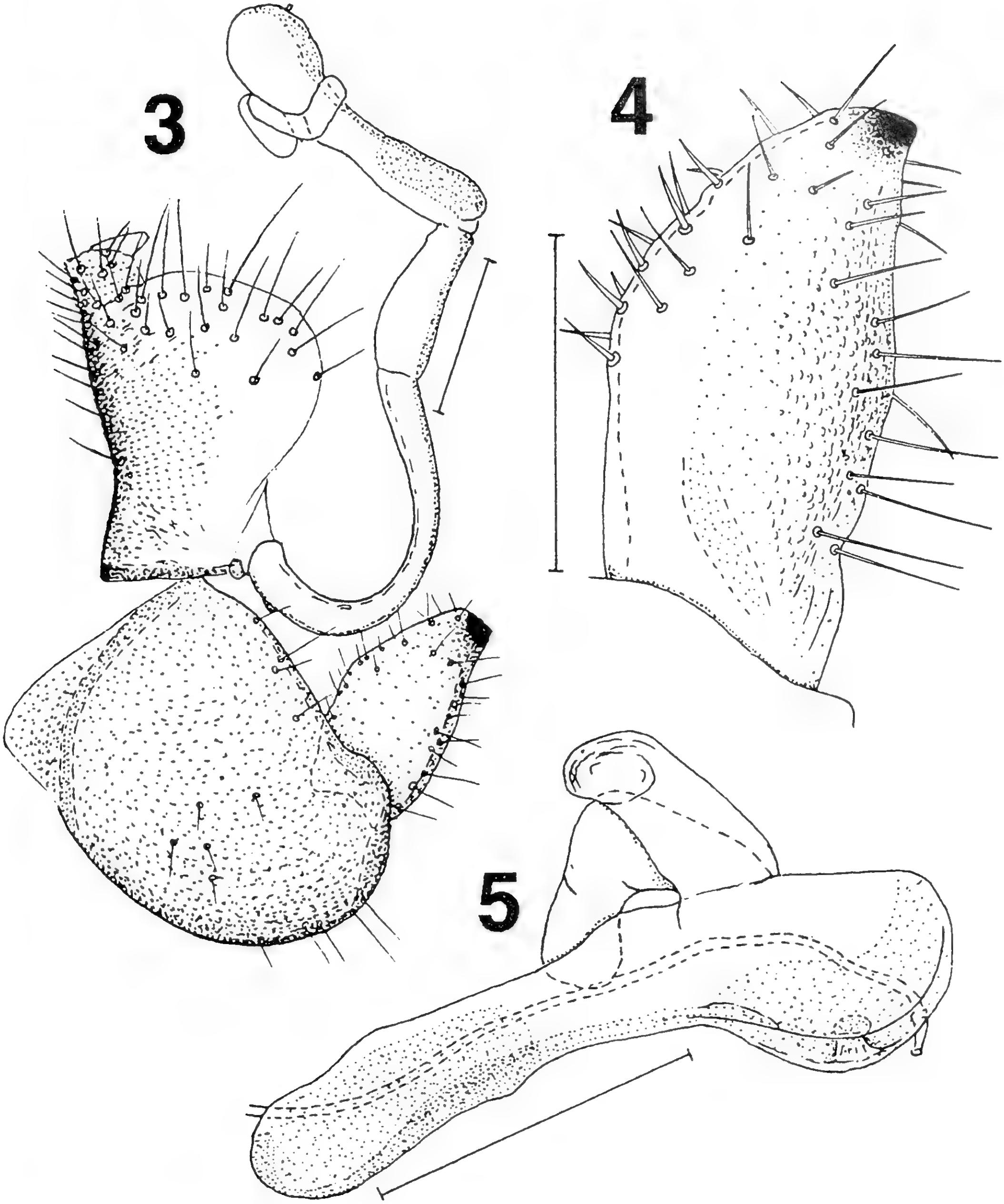
Trioza, a diverse and ubiquitous genus of worldwide distribution (Hollis 1984), includes 45 Nearctic species (Hodkinson 1988). *Trioza chenopodii* can be readily distinguished from all other Nearctic psyllids by its preference for the Chenopodiaceae (only two Nearctic species of *Craspedolepta* are known to feed on chenopods; Hodkinson, 1988:1227) and by its highly characteristic male genitalia (Figs. 3–5). This newly detected chenopod specialist can be recognized as a member of the genus *Trioza* (Triozidae) by the following combination of characters: antenna cylindrical, without long, dark setae; head in dorsal view with vertex short, at most 0.8 times as long as broad, and generally much shorter; genae with conspicuous processes (genal cones) (Fig. 1); forewing with veins Cu1 and M not having a common stem, each arising separately from common origin at vein R (Fig. 2); and forewing without brown color pattern, occasionally uniformly yellow. The following description is taken from Hodkinson and White (1979:75) and Ossiannilsson (1992:324).

Adult.—Extremely variable in color; young specimens generally yellow or yellow-green with brown markings, abdomen often green; in older specimens dorsum often uniformly dark brown. Antenna varying in pigmentation, but generally segments II-V pale, remaining segments brown or black. Seasonally dimorphic: autumn-winter form (*autumnalis*) with short forewings and summer form (*aestivalis*) with forewings normal in length. Metatibia with 3 (arranged 2 + 1) thick, black apical spines. Forewing with surface spinules largely confined to basal half of wing. Shape and surface structure of head as in Fig. 1. Male genitalia (Figs. 3–5): proctiger in lateral aspect with well-developed posterior lobe (Fig. 3); paramere in lateral aspect tapering to acute apex (Fig. 4); apical portion of aedeagus with highly characteristic subapical process (Fig. 5). Female terminalia (Figs. 6–7): proctiger in lateral and dorsal aspects long (Figs. 6–7); circum-anal ring as in Fig. 7. Overall length of male (European literature) 2.10–2.71 mm (form *aestivalis*), of female (European literature) 2.48–3.05 mm (form *aestivalis*). Principal hosts: *Chenopodium, Atriplex,* and *Halimione* (European literature).

For a description of the fifth-instar nymph of both forms (*aestivalis* and *autumnalis*), the reader is referred to Ossiannilsson (1992:324–325).

GEOGRAPHIC DISTRIBUTION

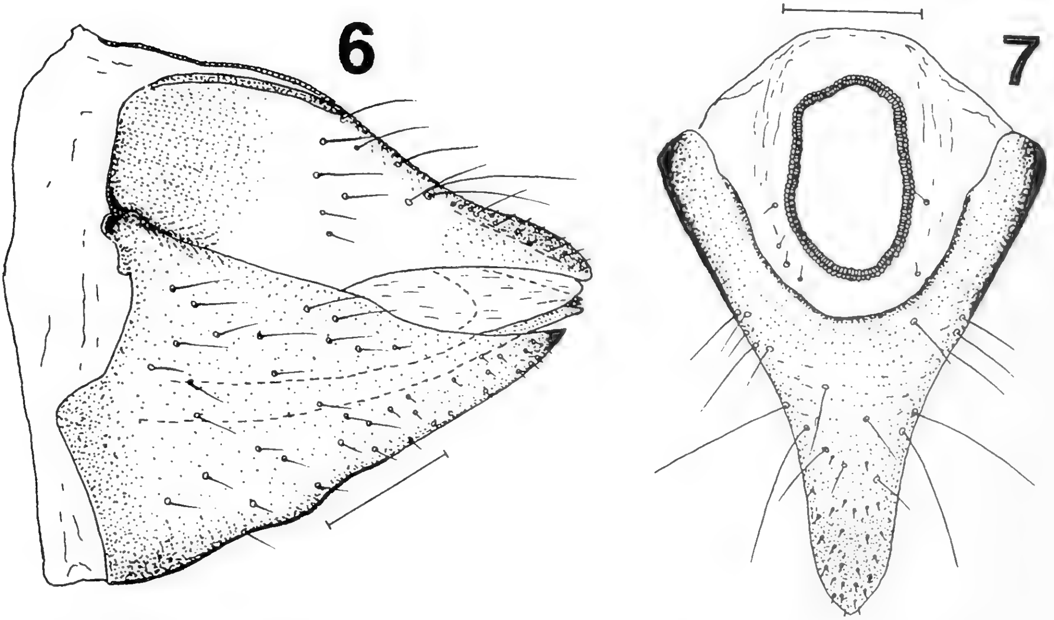
Trioza chenopodii is widespread in the Palearctic Region, occurring in Great Brit-



Figs. 3–5. *Trioza chenopodii,* male (f. *aestivalis*). 3, Terminalia, lateral aspect. 4, Left paramere, lateral aspect. 5, Apical portion of aedeagus (showing subapical process), lateral aspect. Scale lines = 0.1 mm. (From Ossiannilsson, 1992: 324).

ain, most of continental Europe, Canary Islands, Cyprus, the Caucasus and other portions of the former USSR, North India, Pakistan, Iran, Israel, and Egypt (Klimaszewski 1973, Lauterer 1982, Burckhardt 1986, Hodkinson and White 1979, Ossiannilsson 1992).

On July 26, 1995, adults of the long-



Figs. 6–7. *Trioza chenopodii*, female (f. *autumnalis*). 6, Terminalia, lateral aspect. 7, Proctiger (and circumanal ring), dorsal aspect. Scale lines = 0.1 mm. (From Ossiannilsson, 1992: 325).

winged form (*aestivalis*) were found on *Atriplex littoralis* L. (= *A. patula* var. *littoralis* (L.) Gray) growing along the shore at Charlottetown, Prince Edward Island. The 36 adults collected are deposited in the Cornell University Insect Collection, Ithaca, NY (21♀, 9♂), and the National Museum of Natural History, Beltsville, MD (3♀, 3♂).

BIONOMICS

This psyllid is common in ruderal habitats, often between 160 and 300 meters above sea level, where it develops on various Chenopodiaceae. Species of *Chenopodium* and *Atriplex* are the principal hosts (Lauterer 1982, Burckhardt 1986), although it occurs on other chenopods, including *Halimione portulacoides* (L.) Aell. (Hodkinson and White 1979). In the laboratory it has been reared on sugar beet (*Beta vulgaris* L.) and spinach (*Spinacea oleracea* L.), although considerable mortality occurred on the latter plant. Early-instar nymphs are gall formers, feeding within leaf folds on their hosts, but fourth and fifth instars are free feeders on leaves, stems, petioles, and inflorescences (Lauterer 1982). *Trioza chenopodii* is multivoltine over much of its range but apparently produces only two generations in Great Britain and Scandinavia (Hodkinson and White 1979, Lauterer 1982, Ossiannilsson 1992). However, in the plains and foothills of northern Punjab (Rawalpindi area), Pakistan, at least five generations occur on *Chenopodium* spp. between January and October. There, *T. chenopodii* is one of three insects and a fungus that showed great potential as biological control agents of weedy *Chenopodium* in cultivated cereal and vegetable fields (Baloch and Ghaffar 1984).

In the former Czechoslovakia, adults of the shortwinged form overwinter in leaf litter and grasses near the host plants and move onto chenopods in late April or early May. Eggs are laid singly, usually on upper or lower leaf surfaces. Adults of the first summer generation appear from late May to early June. Adults of the first and second summer generations overlap during August. The season's final generation, comprised of shortwinged adults induced by decreasing daylength, may not appear until early November. Thus, Czechoslovakian populations typically consist of two (rarely three) summer (*aestivalis*) generations and one *autumnalis* generation (Lauterer 1982). For additional biological information, including the effects of photoperiod on diapause, the reader is referred to Lauterer's study.

Atriplex littoralis, on which *T. chenopodii* was collected in Prince Edward Island, is also recorded as a host of this psyllid in Europe (Hodkinson and White 1979, Lauterer 1982). This Holarctic chenopod, widespread in North Temperate regions, is regarded as an obligate halophyte (Taschereau 1985). In northeastern North America, diploid coastal populations of *A. littoralis* are thought to be mainly introduced, whereas hexaploid plants occurring in inland saline habitats (and occasionally along the coast) are probably native (Gleason and Cronquist 1991).

MODE OF INTRODUCTION

We consider *T. chenopodii* to have been introduced accidentally into North America, perhaps with ship's ballast, nursery stock, or packing material used in shipping plants. More than 20 other psyllids are believed to be adventive in North America (Downer *et al.* 1988; Hodkinson 1988; Gill 1987, 1991; Pozzi 1988). *Trioza chenopodii,* which appears to be overlooked frequently in Europe (Ossianilsson 1992), might be more widespread in coastal populations of *A. littoralis* in northeastern North America.

ACKNOWLEDGMENTS

We express our appreciation to G. L. Miller (USDA-ARS, Systematic Entomology Laboratory, Beltsville, MD) for verifying our identification of *Trioza chenopodii,* for reviewing the manuscript, and for providing useful comments for improvement, and to P. H. Adler and J. C. Morse (Clemson University, Clemson, SC) for reviewing the manuscript. We also acknowledge the publisher, E. J. Brill (Leiden, The Netherlands), for permission to reproduce Figs. 1–7 from Ossiannilsson's 1992 paper. This is Technical Contribution No. 4236 of the South Carolina Agricultural Experiment Station, Clemson University.

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99(3), 1997, pp. 415–428

TAXONOMY OF *ACIURINA TRIXA* CURRAN (DIPTERA: TEPHRITIDAE) AND ITS LIFE HISTORY ON *CHRYSOTHAMNUS NAUSEOSUS* (PALLAS) BRITTON IN SOUTHERN CALIFORNIA; WITH NOTES ON *A. BIGELOVIAE* (COCKERELL)

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Abstract.—Aciurina trixa Curran is reinstated as a valid taxon and distinguished from *A. bigeloviae* (Cockerell) with which it had been synonymized. The immature stages of *A. trixa* also are described in detail. This tephritid is univoltine and monophagous on *Chrysothamnus nauseosus* (Pallas) Britton. Adults emerge in early spring and lay eggs singly in axillary buds on the current season's branches. First instars eclose in ca. 1 week and tunnel basipetally along a vascular trace into a branch. Gall growth begins during the first larval stadium and continues through the spring and summer. Gall growth was complete by late fall when most branch tunnels and galls contain second instars. Second instars continue to feed in the branch tunnels and begin excavating the gall lumen. Larval growth proceeds through the fall, and by December most galls contain third instars. Third instars confined most of their feeding to the gall, typically filling the branch tunnel with packed frass. Puparia were first observed in mid-February. Pupariation took place within the gall lumen and lasted ca. 2 weeks. Adult females were proovigenic and mated shortly after emergence and repeatedly.

Key Words: Insecta, *Aciurina* taxonomy, immature stages, galls, oviposition behavior, parasitoids

Aciurina trixa Curran is reinstated as a valid species, the immature stages are described for the first time, and a redescription of the adult is provided. The biology, oviposition behavior, distribution, and natural enemies of *A. trixa* are also described for populations occurring in southern California.

MATERIALS AND METHODS

Our field studies of the biology of *A. trixa* were conducted between 1989 and 1994 in southern California. Our primary study and collection locations were Los Angeles County, Pearblossom at ca. 830 m; San Bernardino Co., Cajon Junction at ca. 1000 m, and Pioneertown at ca. 1200 m. Field studies of adult behaviors were conducted at the Cajon Junction site during the spring of 1990–1992 on *C. nauseosus*. Field data were supplemented by laboratory dissections, measurements, and photography of infested host-plant material, and subsequent rearing of adults and their parasitoids.

Twenty-three ova were obtained for study by dissection of gravid, field-collected females. Five first, 20 second, and 18 third instar larvae and two puparia were dissected from infested *C. nauseosus* and all immature stages were examined using scanning electron microscopy (SEM). All specimens for SEM were fixed in 70% EtOH, rehydrated to distilled water in a decreasing series of acidulated EtOH, post-fixed in 2% aqueous osmium tetroxide for 24 h, dehydrated to absolute EtOH in an increasing series of EtOH dilutions, critical-point dried, mounted on stubs, sputter-coated with a gold-palladium alloy and examined on a JEOL JSM C35 scanning electron microscope in the Department of Nematology, University of California, Riverside. Micrographs were prepared on Polaroid P/N 55 film at 15 kV accelerating voltage.

Tephritid names follow Foote et al. (1993), except where amended below; larval terminology follows Headrick and Goeden (1991) and Goeden and Teerink (1996a, b, c); terms for adult behaviors follows Headrick and Goeden (1994); and plant names follow Munz (1968, 1974) and Munz and Keck (1959). Abbreviations used as follows: AMNH–American Museum of Natural History; CAS–California Academy of Sciences; CDFA–California Department of Food and Agriculture; UIM–University of Idaho, Moscow; UCR–University of California, Riverside; WSUP–Washington State University, Pullman. Voucher specimens of adult *A. trixa* and its parasitoids reside in the research collection of RDG. Preserved immature stages are held in the research collection of JAT. Means ± standard errors are provided throughout.

Results and Discussion

Taxonomy

The taxonomy of *Aciurina* species occurring in the western United States has had a tortuous history. Unclear or unknown host-plant associations, variable gall morphology, incorrect insect gall-former attributions, and the recently discovered regional sexual dimorphisms (Goeden and Teerink 1996b, c) have all contributed to the difficulty of elucidating the species comprising this genus. Based on our extensive collections of reared material and examination of museum specimens, many taxonomic issues have recently been clarified (Goeden and Teerink 1996a, b, c).

Although, *A. trixa* has been mentioned in the literature subsequent to its synonymization with *Aciurina bigeloviae* (Cockerell), no formal resurrection of this species has been published. Most recently, notes on the biology, gall formation, and sexual behavior of *A. trixa* were reported from northern Arizona by Fernandez and Price (1994), who cited the work of Dodson and George (1986) for identification of the species that they studied. Foote et al. (1993) remarked that the names synonymized by Steyskal (1984) and Norrbom (1989) were available.

Adult.—Curran (1932) erected the genus *Aciurina* and designated the type species as *A. trixa.* Steyskal (1984) revised the genus and synonymized *A. semilucida* (Bates) (1935) and *A. trixa* with *A. bigeloviae* (Cockerell). Recently, Goeden and Teerink (1996c) resurrected *A. semilucida* based on the discovery of sexually dimorphic wing patterns among disparate populations theretofore unrecognized. This discovery was based primarily on examination of flies individually reared from known galls which reconfirmed the separate species status of *A. semilucida.* Similarly, Dodson and George (1986) provided biological, behavioral, and genetic evidence that *A. trixa* was distinct from *A. bigeloviae* based on flies individually reared from known galls from throughout the southwestern U.S., excluding southern California, but they did not formally resurrect the former species. Our examination of material, reared or otherwise collected, in southern California and museum specimens from all states west of the Rockies, except Oregon, provides more pieces of the puzzle concerning the taxonomic status of *A. trixa.*

The following description supplements the original description of Curran (1932), with characters since recognized as important in separating *Aciurina* species (Steyskal 1984, Foote et al. 1993).

Aciurina trixa Curran
(Fig. 6I)

Female holotype. Head.—White to golden; antenna golden, arista lighter basally, darker apically; bristles as in original description; all uniformly concolorous with head basally, but dark apically.

Thorax.—Dark gray, with uniform covering of gray pollinosity, setulae white. Bristles as given in original description, their location as given in Foote et al. (1993). Scutellum dark brown with posterior apex lighter. Coxae and legs golden; fore-coxa with patch of very fine setae anteriorly; forefemur thickened dorsally, with 2–3 rows of short stout setae, a ventrolateral row of longer setae extending entire length of femora, and at most a single incomplete row of dark setae ventrally (see male description). Wing mostly dark brown with marginal hyaline incisions and internal markings as illustrated by Curran (1932 Fig. 5) (see below for variations). Pterostigma with a proximal hyaline incision; hyaline spot in cell br round; cell cua_1 with 1 large and 2 small marginal hyaline incisions, larger one includes anal lobe; cell m with 2 marginal hyaline incisions, distal incision extends into cell r_{4+5}, often touching vein R_{4+5}.

Abdomen.—Shiny, reddish brown, sparsely covered with very fine yellow bristles, tergite 6 darker, at least in patches, than preceding segments; syntergosternite 7 fuscous to black; aculeus (visible in type) lanceolate without distinct markings or indentations.

Male. Head.—White to golden, vertex darker, ocellar triangle dark; bristles stout, golden; antenna golden, arista golden basally, dark apically.

Thorax.—Dark, fine gray pollinose, setulae short white, dorsocentral seta nearer to postsutural supralar seta than in female; legs golden; fore coxa with anterior patch of fine setae; forefemur thickened, much larger than in remaining legs, larger than female forefemur relative to sizes in remaining legs; rows of stout setae dorsally, ventrolateral row of larger setae extending entire length of femur; ventrally 2–3 rows of short dark setae (possibly aid in securing hold on female during copulation [Dodson 1987]). Wing with marginal hyaline incisions and internal markings similar to that of female (see variations below).

Abdomen.—Brown with darker markings anteriorly, dark around lateral margins, tergite 1 almost completely dark, tergite 5 dark laterally; post-abdomen dark, surstyli golden, prensisetae dark.

Variation.—In males, the head color varies from golden to brown. The setulae of the thorax in both sexes are white or orange. Variation in setulae color among populations of flies was not observed; most specimens, including the holotype of *A. trixa,* have the white form. In California, the specimens reared from small galls all have orange setulae. The thorax color in both sexes varies from light brown to nearly black.

The wing markings varied among the specimens examined. The hyaline or subhyaline incision on the proximal side of the pterostigma can be quite faint among the specimens reared from California. This was also observed among specimens collected (swept or reared) from Idaho. The individuals reared from small galls in southern California were darker than those reared from the larger galls and the infuscation of their wings was heavy. However, even in these flies, a faint mark on the proximal side of the pterostigma was observed, especially on or near the costal vein. The hyaline spot in cell br varies from circular to oblong in *A. trixa.* Only very rarely will specimens (both sexes) have a small infuscation on the wing margin within the proximal hyaline mark in cell m, but it is not elongate and never complete (i.e. bridging the infuscation, thereby forming 2 hyaline incisions from the proximal hyaline mark). In cell c the infuscation can be either narrow or wide with the widest marking being nearly equal in width to the distance between vein S_c and R_1. In approximately ⅓ of the female specimens examined, the wings have three hyaline marks in cell r_1 like *A. trilitura* Blanc and Foote, with only the distal mark either present or absent. Cell

cua_1 typically has 2 small hyaline markings distally and a larger one proximally. The distal hyaline mark in cell m is sometimes constricted at vein M; in a few specimens the constriction is complete and separates the mark in cell m from the mark in cell r_{4+5}. The hyaline mark in cell r_{4+5} can also be constricted and thus bilobed. The mark touches vein R_{4+5} in about half of the specimens examined. In 3 specimens examined, the hyaline mark in cell r_{4+5} is completely constricted forming 2 distinct marks.

Material examined.—*Aciurina trixa:* Female holotype, UTAH: Stansbury I., 13.vi.13 (AMNH). CALIFORNIA: Inyo Co., Grapevine Canyon, 2 males 1 female, 20.v.1988, (R. D. Goeden) (UCR); Lone Pine, 1 male, no gall, 1.vi.1937, (E. P. Van Duzee) (CAS). Kern Co., Cane Brake Valley, W. Side Walker Pass, 3,000 ft., 1 female and 1 male with gall, 1 female without gall, *Chrysothamnus nauseosus,* 9.xi.70, (J. T. Howell) (CAS); Spanish Needle Creek, 3 females with galls, 6 males with galls, 11.iv.1989, (R. D. Goeden) (UCR); Walker Pass, 1 male with gall, 11.iv.1989, (R. D. Goeden) (UCR). Los Angeles Co., Pearblossom, 7 males with galls, 5 females with galls, 18.ii.1987, (R. D. Goeden) (UCR). Maricopa, Co., 9 females, 2 males, 31.iii.1931, (E. P. VanDuzee) (CAS). San Bernardino, Co., Barstow, 1 female, "Ex. *Artemisia*", 16.iv.1938, (T. G. H. Aitken) (CAS); Forest Falls, 7 females with galls, 2 males with galls, 3.v.1988, (R. D. Goeden) (UCR). San Luis Obispo Co., Maricopa Grade, 4 males with galls, 3 females with galls, 21.iii.1931, (E. P. VanDuzee) (CAS). Santa Barbara Co., Ventucopa, 2 females with galls, 25.iii.1959, (R. P. Allen) (CDFA). COLORADO: Grand Junction, 1 female, 20.vi.01, (WSUP). Salida, 28.vi.1933, 3 females 3 males, "ex *Chrysothamnus*", (Cockerell) (WSUP). IDAHO: All with galls: Bear Lake Co., Dingle, 1 female, 17.vi.1975, (J. T. Wangberg) (UIM). Boise Co., Horseshoe Bend, 3 females, 21.v.1975, (J. T. Wangberg) (UIM). Box Elder Co., Strevell, 1 male, "*C. nauseosus*", 19.iii.1974, (J. T. Wangberg) (UIM). Butte Co., Howe, 2 males, "*C. nauseosus*", 27.iii.67, (E. J. Allen) (UIM). Franklin Co., Preston, 1 male, 18.iii.1974, (J. T. Wangberg) (UIM). Idaho Co., Lucille, 1 male, 2 females, 12.iv.1975; 2 males, 24.iii.1974; 2 females, 28.iv.1974, (Wangberg) (UIM); Riggins, 1 female, 29.iv.1974, (J. T. Wangberg) (UIM); Slate Creek, 1 male, 20.v.1975, (J. T. Wangberg) (UIM). Lemhi Co., Leadore, 1 female, 2 males, 21.vi.1975, (J. T. Wangberg) (UIM). Oneida Co., Stone, 1 female, "*C. nauseosus*", 19.iii.1974, (J. T. Wangberg) (UIM). Owyhee Co, Walters Ferry, "*C. nauseosus*", 5 females, 3 males, 31.iii.1967, (E. J. Allen) (UIM). Bruneau, 1 female, 26.vi.1974, (J. T. Wangberg) (UIM). Twin Falls Co., Twin Falls, 1 female, 29.iii.1967, (E. J. Allen) (UIM). NEVADA: Washoe Co., Hills just N. of Sparks, 1 male, 1 female, 1 gall, (J. T. Howell) (CAS). NEW MEXICO: Santa Fe, 2 males, 21.vi.1926, (E. C. VanDyke) (CAS). UTAH: Provo, 1 female, 1.v.1963, (WSUP). Female Paratype: Collinston, 21.vii.1927, "Det. Curran" (G. F. Knowlton) (AMNH). WASHINGTON: Okanogah Co., 1 female, no gall, 19.v.1968, (WSUP). Whitman Co., Steptoe Cyn., 1 female, no gall, 17.v.1973, (WSUP).

Aciurina bigeloviae. ARIZONA: Flagstaff, 1 male, no gall, 28.vi.1971, (E. Klee) (CAS). NEVADA: Reno, 1 female with gall, 9.v.1891, (F. Hilman) (CAS).

Diagnosis—*Aciurina trixa* is variable in its adult morphology and the morphology of the galls it induces on its host plant, *Chrysothamnus nauseosus. Aciurina trixa* can be distinguished from its closest relative, *A. bigeloviae,* based primarily on gall type, and for the majority of specimens by the presence of a hyaline mark on the proximal side of the pterostigma and by the absence of an elongate or dividing mark within the proximal hyaline spot in cell m, [see also Fig. 1 in Dodson and George (1986)]. This distinction makes *A. bigeloviae* a rare species known only from large cottony galls and restricts its range to exclude California. However, one record indicates its range may extend into northeastern California along the edge of the Great Basin (Foote and Blanc 1963).

Aciurina trixa differs from *A. semilucida* by having multiple hyaline spots in cell r_{2+3} (cf. Goeden and Teerink [1996c], Fig. 1A–E) or from females of *A. semilucida* occurring in California by not having the distal hyaline spot in cell m extend beyond vein R_{4+5} into cell r_{2+3} (cf. Goeden and Teerink [1996c], Fig. 1F). *Aciurina semilucida* is known to form galls on *Chrysothamnus viscidiflorus* (Hooker) Nuttall and *C. nauseosus* (Foote et al. 1993). *Aciurina semilucida* galls are readily distinguishable from galls of *A. bigeloviae* and *A. trixa* by being light green, pyriform with an attenuated apex, covered with a uniform, light-colored pubescence, and bearing several basal leaves (Goeden and Teerink 1996c).

Both *A. trixa* and *A. bigeloviae* are known only from *C. nauseosus*; however, the galls they induce are readily distinguishable and is the best character for species recognition. *Aciurina bigeloviae* is known to form only large, cottony galls [see also Dodson and George (1986), Figure 2B] that sometimes bear small leaves studding the gall body, rather than a rosette of basal leaves as in *A. semilucida* (Goeden and Teerink 1996c). The tomentum of *A. bigeloviae* galls is thick and continuous over the entire gall, appearing like a wad of cotton. *Aciurina bigeloviae* galls have been collected from several sites in Idaho, Colorado, Arizona, New Mexico and Utah; however, most specimens in collections do not have the galls from which they were reared. The galls of *A. maculata* (Cole) also occur on *C. nauseosus* and are cottony; however, they are much smaller than *A. bigeloviae* galls and the adults are readily distinguishable (Foote et al. 1993).

No cottony tephritid galls have ever been found on *C. nauseosus* in southern California (RDG, unpublished data). The galls of *A. trixa* vary in external morphology throughout its range. At present we can distinguish two types of galls in southern California. There are reportedly three gall forms in Idaho (Wangberg 1981). Galls in southern California have a waxy or resinous outer layer. The most common whitish (pearly) gall found in California is shown in Fig. 6B. The smaller, brownish gall has a more restricted distribution, occurring on the north slope of the San Bernardino Mountains bordering the Mojave Desert (shown dissected in Fig. 6G, H).

The key to species of *Aciurina* as given in Foote et al. 1993 is modified to include the resurrection of *A. trixa* (figures cited are from Foote et al. 1993, except as noted).

10. Pterostigma along costa no more than 1.5 times as long as its greatest width (Fig. 121, c); vein dm-cu nearly straight (Fig. 121, e), the lower apical angle of cell dm about 65° (Fig. 121, f); wing predominantly hyaline . . . . *notata* (Coquillett)
    Pterostigma along costa at least 2.0 times as long as its greatest width (Fig. 124, a); vein dm-cu usually bowed apicad (Fig. 124, b), the lower apical angle of cell dm seldom less than 90° (Fig. 124, c); wing patterned 11
11. Galls without tomentum; pterostigma of at least one wing with a proximal hyaline or subhyaline incision (can be very faint and only on and slightly extending from costa) (Fig. 124; Dodson and George, Fig. 1c); proximal marginal hyaline incision in cell m usually lacking median, dark mark . . *trixa* Curran
    Galls with cottony tomentum, pterostigma and costa dark from Sc to R_1 in most specimens (Fig. 122, b); proximal marginal hyaline incision in cell m usually with a median, dark, often elongate mark (Fig. 122), which sometimes divides the incision (Steyskal 1984, Fig. 13) (Dodson and George 1986; Fig. 1a, b, d) . . . . *bigeloviae* (Cockerell)

Immature stages. Egg.—White, elongate-cylindrical with narrow, parallel-sided, short pedicel and bluntly rounded, basal end (Fig. 1A). Pedicel with ring of multipored aeropyles and micropyle at apex (Fig. 1B). Chorion with slightly elevated striations on pedicel.

First instar.—Translucent white, globose, bluntly rounded anteriorly and posteriorly, three to four rows of acanthae circumscribe

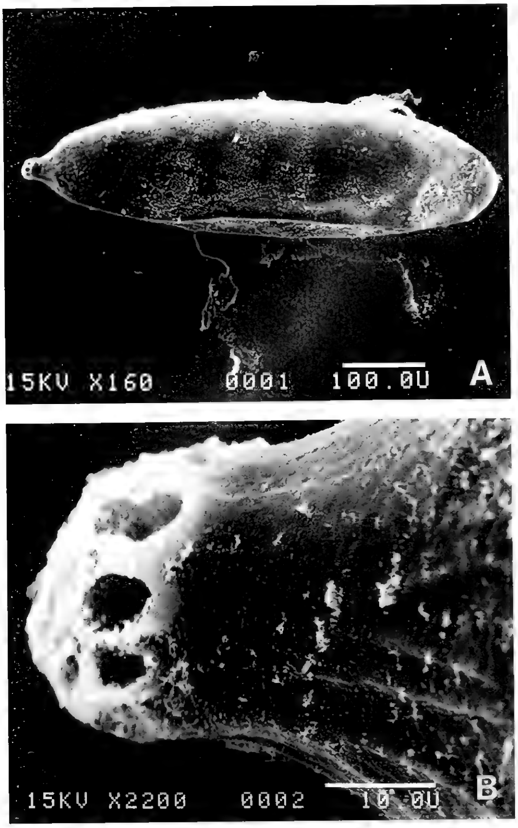

Fig. 1. Egg of *Aciurina trixa*. (A) Habitus; (B) pedicel.

the body at intersegmental lines, lateral midline with up to four rows of acanthae (Fig. 2A). Gnathocephalon conical, rugose pads absent (Fig. 2B). Mouth hook with two teeth (Fig. 2B-1), cushioned by an integumental petal (Fig. 2B-3), median oral lobe present (Fig. 2B-2). Anterior sensory lobe with four sensory organs (Fig. 2B-4), dorsal sensory organ comprised of single papilla (Fig. 2B-5). Stomal sense organ laterad of mouth lumen bearing sensory papillae (Fig. 2B-6). Posterior spiracular plates contiguous, rounded, and protuding; each plate bears two rimae (Fig. 2C-1) and typically four, spine-like, interspiracular processes (Fig. 2C-2). Compound sensilla ventrad of spiracle each comprised of two stelex sensilla (Fig. 2C-3).

Second instar.—White, oblong-elliptical, bluntly rounded anteriorly and posteriorly,

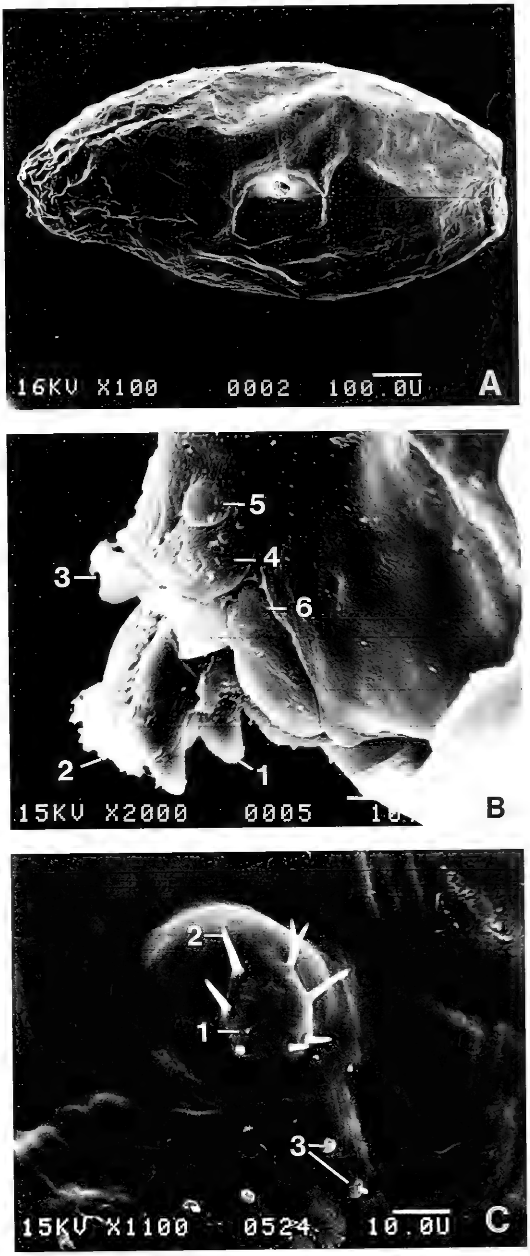

Fig. 2. First instar of *A. trixa*. (A) Habitus, anterior to left; (B) gnathocephalon, lateral view, 1—mouthhooks, 2—median oral lobe, 3—integumental petal, 4—anterior sensory lobe, 5—dorsal sensory organ, 6—stomal sense organ; (C) caudal segment, 1—rima, 2—interspiracular process, 3—compound sensilla.

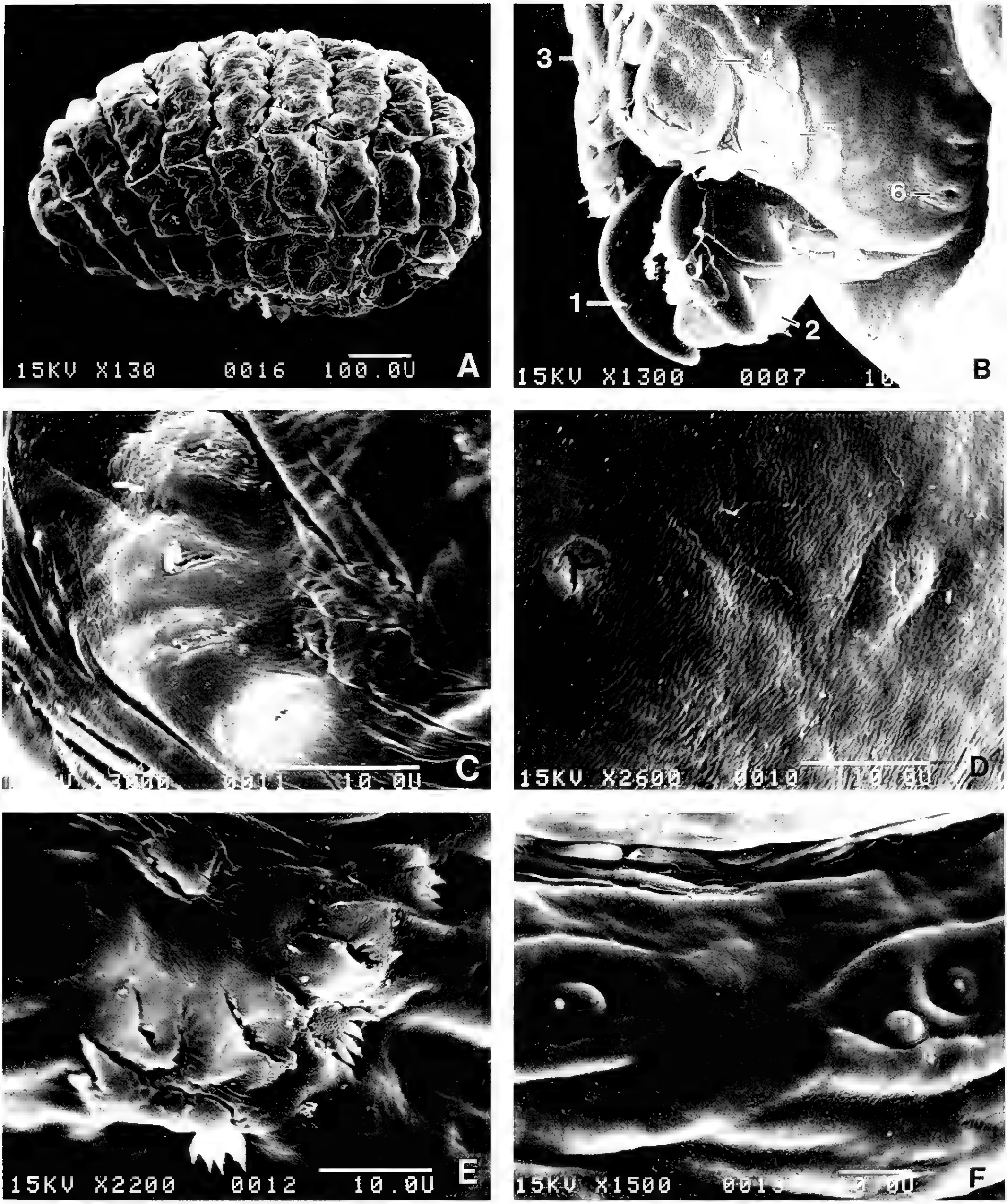

Fig. 3. Second instar of *A. trixa.* (A) Habitus, anterior to left; (B) gnathocephalon, lateral view, 1—mouthhook, 2—median oral lobe, 3—dorsal sensory organ, 4—anterior sensory lobe, 5—stomal sense organ, 6—lateral sensory organ; (C) anterior prothoracic spiracle; (D) lateral spiracular complex, spiracle to left, (E) posterior spiracular plate; (F) compound sensilla.

several rows of acanthae circumscribe the body at intersegmental lines (Fig. 3A). Gnathocephalon conical, smooth, except for rugose pads surrounding stomal sense organ. Mouth hooks bidentate (Fig. 3B-1), median oral lobe rounded anteriorly, fleshy ventral lobe attached basally to the labial lobe (Fig. 3B-2). Dorsal sensory organ comprised of single papilla (Fig. 3B-3), anterior sensory lobe with four sensory organs (Fig. 3B-4), stomal sense organ with three to five sensilla (Fig. 3B-5), lateral sensillum with single verruciform papilla (Fig. 3B-6). Prothorax smooth, anterior thoracic spiracle with three to four papillae (Fig. 3C). Lateral spiracular complex on mesothorax with one spiracle and two verruciform sensilla; metathorax and abdominal segments I–VII with one spiracle and one verruciform sensillum (Fig. 3D). Posterior spiracular plate with three rimae and four, single or multibranched, interspiracular processes (Fig. 3E). Compound sensilla comprised of two stelex sensilla (Fig. 3F).

Third instar.—White, oblong-elliptical, bluntly rounded on both ends, acanthae restricted to area around intersegmental lines (Fig. 4A). Mouth hooks bidentate (Fig. 4B-1), median oral lobe with numerous fleshy protuberances on ventral lobe, attached basally to labial lobe (Fig. 4B-2). Gnathocephalon smooth, with rugose pads laterally and ventrally near mouth lumen (Fig. 4B). Dorsal sensory organ with a single papilla (Fig. 4C-1), anterior sensory lobe with four sensory organs (Fig. 4C-black lines), stomal sense organ invested with sensoria (Fig. 4C-2). Prothorax smooth, anterior thoracic spiracle with three to four non-protruding papillae, each with a single slit, ecdysial scar visible (Fig. 4D). Lateral spiracular complex with single spiracle and verruciform sensillum (Fig. 4E). Posterior spiracular plate with three rimae, and reduced interspiracular processes (Fig. 4F). Compound sensilla nearly contiguous, each with two reduced stelex sensilla.

Puparium.—Shiny; dark fuscous to black, some with lighter brown around the middle; elongate-reinform, bluntly rounded on both ends, 4.0 ± 0.1 (3.1–4.3, $n = 9$) mm long and 2.0 ± 0.1 (1.7–2.2, $n = 8$) mm wide (Fig. 5A). Anterior end with invagination scar and anterior thoracic spiracle (Fig. 5B); posterior end with spiracular plates non-protruding (Fig. 5C).

Diagnosis.—The immature stages of *Aciurina thoracica* Curran (Headrick and Goeden 1993), *A. ferruginea* (Doane) and *A. michaeli* Goeden (Goeden and Teerink 1996a), *A. idahoensis* Steyskal (Goeden and Teerink 1996b), and *A. semilucida* (Bates) (Goeden and Teerink 1996c) have been described in detail. *Aciurina trixa* is the last, described California species of *Aciurina* to be examined by us. The egg of *A. trixa* is smooth, nearly parallel-sided, with a pedicel ca. 0.015 mm in length. The eggs of *A. ferruginea, A. michaeli, A. idahoensis* and *A. semilucida* have elongate pedicels; the pedicel of the latter being ca. half as long as the other species with elongate pedicels. The egg of *A. thoracica* has a short pedicel and heavy reticulation on the pedicel end that diminishes to a smooth surface near the midpoint of the egg body.

The third instars of *A. michaeli* and *A. semilucida* have abdominal segments III–V expanded dorsally producing an "ambulatory hump." No other *Aciurina* species in California have this feature. The integument of *A. trixa* has minute acanthae restricted to the areas around the intersegmental lines; however, *A. thoracica* has acanthae in patches between the intersegmental lines. *Aciurina idahoensis, A. semilucida* and *A. ferruginea* have acanthae restricted to the ventral surface, and *A. michaeli* has acanthae ventrally and laterally.

The number of sensilla associated with the lateral spiracular complexes on the meso- and metathorax and abdominal segments I–VII (= sensilla formula) differs among the *Aciurina* species studied. The sensilla formula, i.e. the number of lateral spiracular sensilla on the mesothorax, the metathorax, and the abdominal segments (a '?' indicates we were unable to locate the sensilla), for *A. michaeli* is 1, 1, 0; for *A. ferruginea* is 3, 3, ?; for *A. thoracica* is ?, 1, 1; for *A. idahoensis* is ?, 1, 0; for *A. semilucida* is 2, 2, 1; and for *A. trixa* is 2, 1, 1. The anterior prothoracic spiracles differ in the number of papillae among the species studied. *A. michaeli* has 3–4, *A. ferruginea* has 5, *A. thoracica* has 4, *A. ida-*

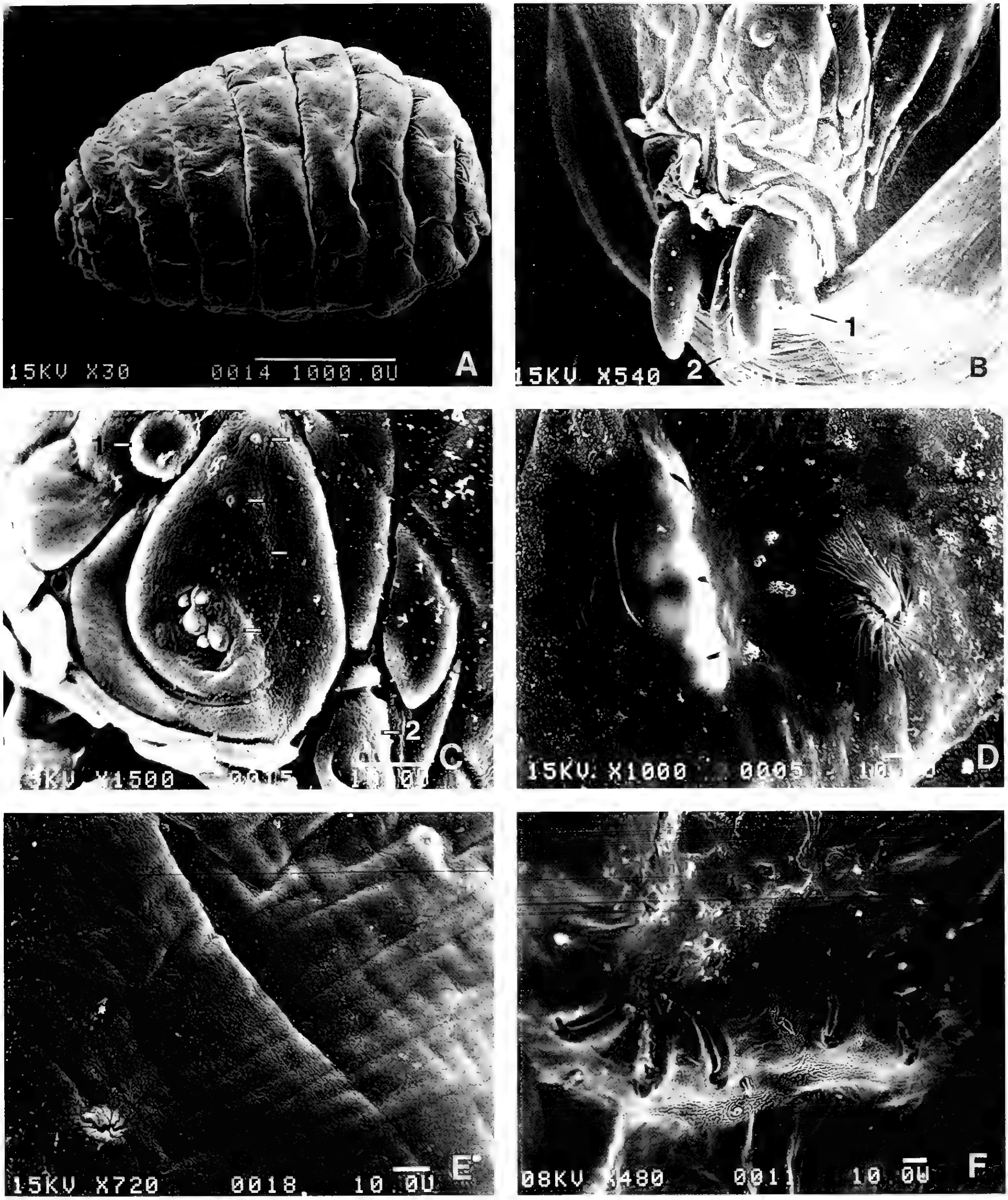

Fig. 4. Third instar of *A. trixa.* (A) Habitus, anterior to left; (B) gnathocephalon, anterior view, 1—mouthhook, 2—median oral lobe; (C) sensory structures of the gnathocephalon, 1—dorsal sensory organ, 2—stomal sensory organ; (D) anterior prothoracic spiracle; (E) lateral spiracular complex, spiracle on left; (F) caudal segment with posterior spiracular plates.

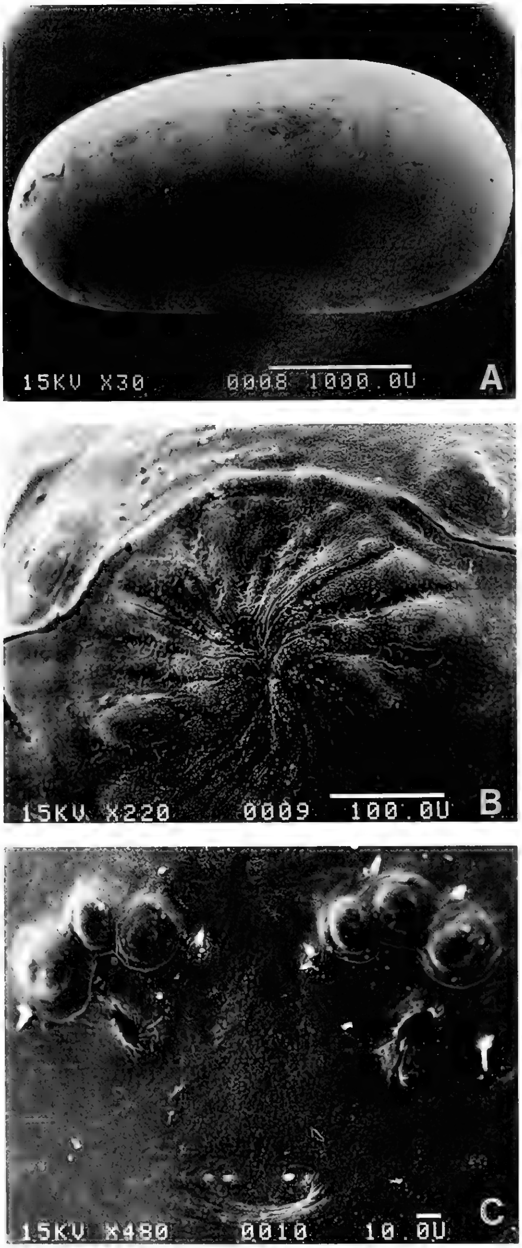

Fig. 5. Puparium of *A. trixa.* (A) Habitus, anterior to left; (B) anterior invagination scar; (C) posterior spiracular plates.

hoensis has 3–5, *A. semilucida* has 3, and *A. trixa* has 4 non-protruding papillae. The first and second instars, and the puparia do not differ significantly in their morphology among the species studied in California.

Biology

Egg.—The eggs of *A. trixa* were laid singly into axillary buds on the current season's branches (Fig. 6A) soon after adult emergence in the spring in southern California (Table 1). The eggs were inserted partially into the tissues or among and parallel to the bud scales leaving the pedicel-bearing ends exposed. Eclosion occurred within 1 week after oviposition. The embryo turned 180° and the first instar exited basally, directly into the plant tissues.

Dodson (1987) reported that *A. trixa* females in New Mexico also laid eggs singly in axillary buds of *C. nauseosus* with galls becoming visible in August. Fernandez and Price (1994) reported that oviposition occurred in the field between late April and mid-August in northern Arizona and that eggs were laid singly in axillary buds.

First instar.—The first instar tunnelled into the axillary bud tissues and continued down the vascular trace into the branch basipetally in the phloem between the epidermis and cambium. The feeding of the first instar stimulated the phloem and epidermis outside of the woody vascular cylinder surrounding the pith to expand, which resulted in the branch swelling at and near the axillary bud. Branch swelling was rapid and ceased when the first larval stadium ended. Branch swelling was also reported by Fernandez and Price (1994). Branch tunnel feeding concurrent with gall growth was also reported by Dodson (1987) and Fernandez and Price (1994).

The bud scales remained as small swellings at the base of galls. Gall growth continued through the spring and summer (April–September, Table 1) as the first instar excavated its tunnel within the branch from the base of the axillary bud basipetally. Thus, gall growth appeared to begin and proceed even though no larval feeding took place directly within the gall. Branch tunnels containing first instars averaged 3.1 ± 0.3 (range, 2.7–3.6; $n = 3$) mm long. Galls associated with branch tunnels containing

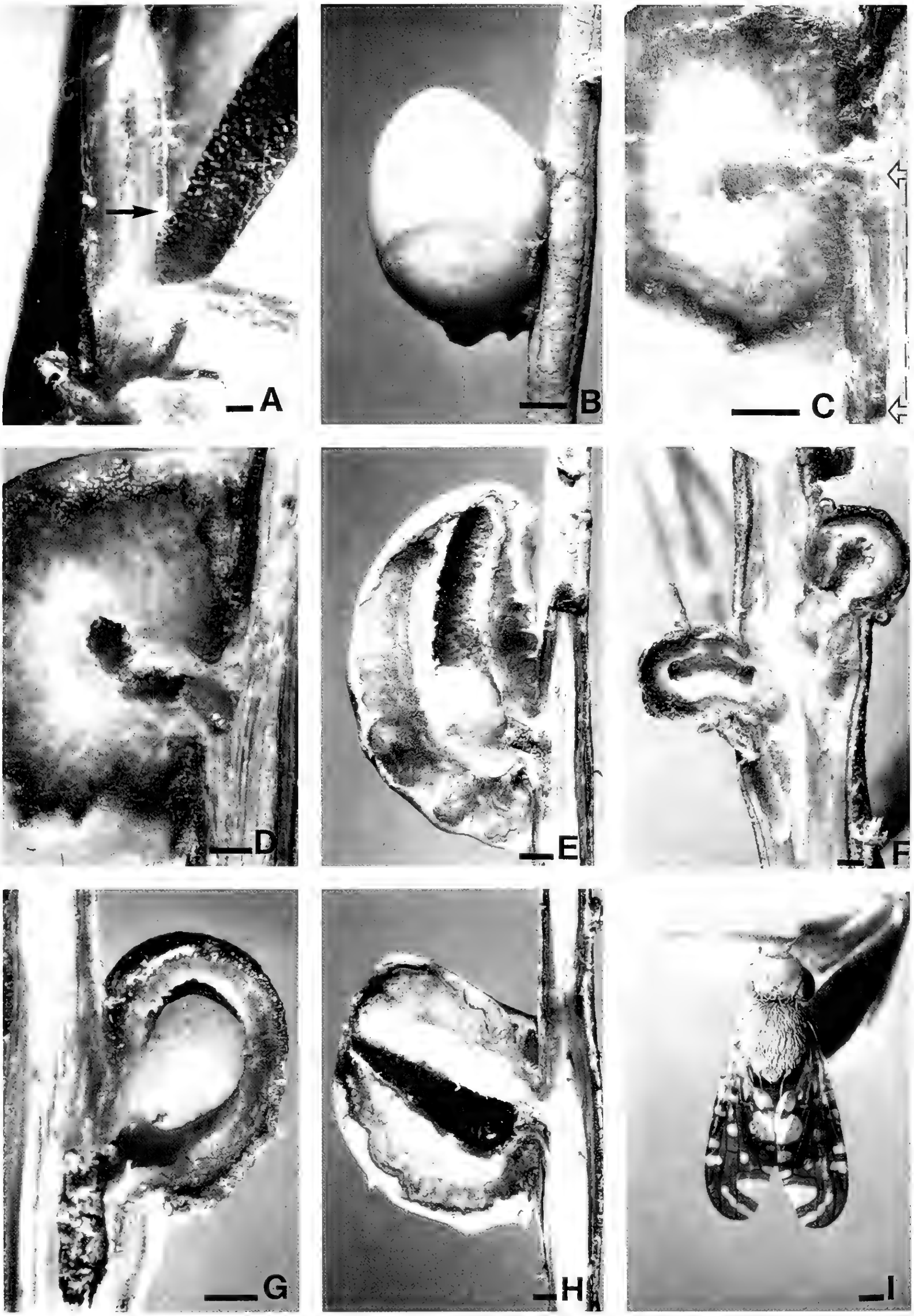

Fig. 6. Life stages of *A. trixa.* (A) egg inserted between leaf primordia (arrow); (B) mature gall, large, smooth, pearly, gall-type; (C) second instar feeding tunnel (arrows indicate beginning and end of tunnel) and partially excavated gall cavity; (D) second instar feeding in gall cavity and branch tunnel; (E) third instar in gall with exit tunnel formed apically and branch tunnel packed with frass; (F) second instars in small type of galls; (G) third instar in small gall-type; (H) puparium within gall locule, with anterior end facing exit window; (I) adult female of *A. trixa.* Bars indicate ca. 1 mm.

Table 1. Phenological development of *Aciurina trixa* on *Chrysothamnus nauseosus* in southern California. i—first instar; ii—second instar; iii—third instar.

Month											
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
eggs	eggs										
	i	i	i	i	i	i	i				
						ii	ii	ii	ii	ii	
								iii	iii	iii	iii
											puparium
adult	adult										

first instars measured 3.3 ± 0.2 (range, 2.8–3.6; $n = 6$) mm in diameter. First instars confined most of their feeding to the branch tunnel, as was also reported by Fernandez and Price (1994). Although galls were nearly full-size by the end of the first stadium in September or October (Table 1, Fig. 6B), gall locule excavation was begun only by the late first instars. This too, is consistent with the findings of Dodson (1987) and Fernandez and Price (1994). Gall locules averaged 0.96 ± 0.03 (range, 0.9–1.0; $n = 3$) mm wide.

Second instar.—By late October/early November gall growth was complete (Table 1). Dodson (1987) and Fernandez and Price (1994) also reported that gall growth was complete by November in New Mexico and Arizona, respectively. Galls containing second instars averaged 3.4 ± 0.07 (range, 2.3–4.1; $n = 31$) mm in diameter. The second instar continued to feed within the branch tunnel, enlarging it and extending its length basipetally (Fig 6C). Branch tunnels containing second instars averaged 3.3 ± 0.15 (range, 2.0–6.0; $n = 28$) mm long. The second instar also moved from the branch tunnel into the fully-formed gall and began excavating the gall lumen (Fig. 6D). The swelling around the branch tunnel did not increase with the continued feeding of the second instar.

As the gall lumen was enlarged, the inner walls became smooth; however, a substantial amount of parenchymatous tissue remained. Lumens of 28 galls containing second instars averaged 1.3 ± 0.08 (range, 0.5–2.5) mm wide and 3.16 ± 0.3 (range, 1.6–4.3) mm long. Frass accumulated within the gall lumen and in the branch tunnel as feeding continued. Frass was moved into the tunnel from the gall and packed into the basal end of the tunnel. The cast exuviae and cephalopharyngeal skeletons of first instars also were found within the packed frass. One late-second instar was observed beginning to form the exit tunnel in the gall, evidenced as a narrow tunnel toward the apex of the gall.

Third instar.—Larval growth proceeded through the fall, and by December most galls contained third instars (Table 1). Seventy galls containing third instars averaged 3.8 ± 0.06 (range, 2.6–5.0) mm in diameter. After the second molt, the third instars confined most of their feeding inside the gall, and the branch tunnel was used for frass storage (Fig. 6E). The gall walls were reduced in thickness by the feeding of the third instar. Lumens of 65 galls containing third instars averaged 2.3 ± 0.07 (range, 1.1–3.7) mm wide and 3.8 ± 0.07 (range, 2.5–5.4) mm long.

Third instars completed the exit tunnel by excavating up to the epidermis to form a circular window for adult emergence (Fig. 6E). The formation of exit tunnels by third instars was also reported by Dodson (1987) and Fernandez and Price (1994). Most windows were formed at or near the apices of galls.

Larval development and feeding, gall formation and growth, and phenological development were similar for both gall types occurring in southern California (Fig. 6F, G). The smaller gall type has not been reported to occur outside of southern California (Dodson 1987, Fernandez and Price 1994).

Puparium.—Puparia were first observed beginning in mid-February and the puparial stage lasted ca. 2 weeks (Table 1). The puparium was formed in the lumen of the gall (Fig. 6H); no puparium was observed in a branch tunnel. The cephalic end of the puparium was oriented toward the window.

Adult.—Adults (Fig 6I) are circumnatal (Headrick and Goeden 1994) and emerged in early spring (March–April, Table 1) following winter rainfall. Males were protandrous and awaited female emergence by perching near galls. Males lived an average of 32.1 ± 4.0 (range, 3–57; n = 18) days; females lived an average of 28.0 ± 5.3 (range, 13–43; n = 6) days. Courtship and mating behavior will be described and analyzed in a separate paper.

Females are proovigenic and emerge with a full complement of eggs. Mating was observed in the field when females were still teneral and was repeated throughout their lifetimes. Oviposition behavior was distinctive. Females walked or flew to the base of a branch and then walked towards its apex. At or near the top of the branch, they then turned and walked down the branch. At the first axillary bud, they stopped and probed with the oviscape bent downward and extruded the aculeus. If the site was suitable, a female oviposited a single egg after extending the aculeus into the bud, either piercing the bud tissues or inserting the egg between the leaf primordia. After oviposition, females groomed, then moved downward to the next axillary bud and repeated this procedure. Females did not lay eggs into every axillary bud probed. Females continued basipetally in this manner until the base of the branch was reached, and then either walked or flew to another branch. Males stalked ovipositing females and attempted and usually successfully mated with them at any point during the above oviposition sequence.

Natural enemies.—The following were reared from galls as primary, larval-pupal, solitary endoparasitoids: *Halticoptera* sp. (Pteromalidae), *Eurytoma* sp. (Eurytomidae), *Torymus* sp. (Torymidae), *Aprostocetus* sp., (Eulophidae), *Brasema* sp. (Eupelmidae) and undetermined species of Platygastridae and Petromalinae. A gregarious species of *Pronotalia* sp. (Eulophidae) was reared as a primary, larval-pupal, endoparasitoid from galls of *A. trixa*. Some mortality observed in the field was attributed to bird predation on the mature galls.

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A NEW GENUS AND REDESCRIPTIONS FOR AFRICAN SPECIES PREVIOUSLY PLACED IN *ACENTRELLA* (EPHEMEROPTERA: BAETIDAE)

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Abstract.—Within the Ephemeroptera family Baetidae, ***Demoreptus,*** new genus, is erected to accommodate *D. capensis* (Barnard), **new combination,** *D. monticola* (Crass), **new combination,** and *D. natalensis* (Crass), **new combination.** These species were originally described from southern Africa and assigned to *Acentrella* Bengtsson. *Demoreptus* is distinguished from *Acentrella* in the larval stage by having apicolaterally prolonged and attenuated fused incisors and relatively long, well-demarcated labial palp segments and in the adult stage by having a small, rounded process anteriorly on the mesoscutum. The larval stage of each species in *Demoreptus* is redescribed and a key to the species is provided. Analysis of interspecific relationships indicates that *D. capensis* is the most plesiotypic species, and that *D. natalensis* and *D. monticola* represent derived sister species.

Key Words: Ephemeroptera, Baetidae, *Demoreptus,* new genus, new combinations, Africa

The *Baetis* complex (Ephemeroptera: Baetidae) is a monophyletic grouping of genera comprised of *Acentrella* Bengtsson, *Baetiella* Uéno, *Baetis* Leach, *Barbaetis* Waltz and McCafferty, *Cymulabaetis* McCafferty and Waltz, *Gratia* Thomas, *Heterocloeon* McDunnough, *Labiobaetis* Novikova and Kluge, *Liebebiella* Waltz and McCafferty, *Platybaetis* Müller-Liebenau, and *Tanzaniella* Gillies. The complex is defined by the possession of the villopore, located on the ventral margin near the base of the larval femora (see, e.g. Waltz and McCafferty 1987: Figs. 1, 4, 5, 12, 17). Precise phylogenetic relationships within the complex, however, remain unknown.

The *Baetis* complex is relatively common and diverse in the Holarctic and Orient, but it is poorly known in the Neotropics and Australia. In the Afrotropics, the genera *Acentrella, Baetis, Pseudocloeon,* and *Tanzaniella* have been variously treated by Barnard (1932, 1940), Crass (1947), Kimmins (1955, 1960), Demoulin (1970), Kopelke (1980), and Gillies (1991, 1993, 1994). Only one species has been described in the poorly known genus *Tanzaniella* (Gillies 1991), and, as Waltz and McCafferty (1987) and McCafferty and de Moor (1995) pointed out, the taxonomic status of species assigned to *Acentrella, Baetis,* and *Pseudocloeon* are in need of re-evaluation. This situation remains the same even though Gillies (1994) transferred all African species of *Pseudocloeon* to *Baetis.*

In this study, we address the African species that were described in the genus *Acentrella: A. capensis* Barnard, *A. monticola* Crass, and *A. natalensis* Crass. Those species proved to be referable to a new genus described herein. We additionally redescribe the larval stage of each species and provide a key for their identification. Materials examined are housed in the Albany Museum (AM), Grahamstown, Eastern Cape Province, South Africa, and the Purdue Entomological Research Collection (PERC), West Lafayette, Indiana, U.S.A.

Demoreptus Lugo-Ortiz and McCafferty, new genus

Larva (Fig. 1).—Head: Antennae 1.0–2.0× length of head capsule. Labrum with deep (Figs. 3, 16) or shallow (Fig. 9) anteromedial notch. Mandibles with apicolaterally prolonged and attenuated fused incisors, with distinct but poorly developed denticulation (Figs. 4, 5, 18, 19) or adenticulate and bladelike (Figs. 11, 12). Maxillae (Figs. 6, 13, 20) with palps two segmented. Labium (Figs. 7, 14, 21) with relatively long glossae and paraglossae; palps relatively long, extending beyond apices of glossae and paraglossae; palp segment 2 with poorly defined distomedial lobe; palp segment 3 width not exceeding that of apical width of segment 2 (Figs. 7, 21) or medially broader than apical width of segment 2 (Fig. 14). Thorax: Hindwingpads rudimentary to well developed. Legs with villopore present; femora with long, fine, simple setae dorsally; tarsi twisted; tarsal claws with single row of denticles and two subapical short, fine, simple setae. Abdomen: Terga without scales or scale bases; posterior marginal spines poorly defined. Gills on abdominal segments 1–7, platelike, poorly tracheated, marginally smooth (Fig. 23). Paraprocts (Figs. 8, 15, 24) without marginal spines. Two caudal filaments present, with abundant setae medially; medial caudal filament reduced to one segment.

Adult.—Mesoscutum with small, rounded anterior process in lateral view (Fig. 2). Forewings with paired marginal intercalaries. Hindwings present, except in males of *D. natalensis*; when present, with (Barnard 1932: Fig. 12b) or without (Crass 1947: Fig. 16b, 18b) costal process. Male genital forceps (Crass 1947: Fig. 17h) three segmented; segment 2 strongly bowed inwardly; segment 3 ellipsoidal.

Etymology.—We are honored in naming this genus after Ferdinand C. de Moor, for his support of the study of aquatic insects in South Africa. The name consists of an arbitrary combination of letters that incorporates a Latinization of our colleague's last name and the Latin suffix *reptus* (to crawl), which is an allusion to the behavior of the larvae.

Type species.—*Demoreptus natalensis* (Crass), 1947: 72.

Species included.—*Demoreptus capensis* (Barnard), **new combination**; *D. monticola* (Crass), **new combination**; *D. natalensis* (Crass), **new combination.**

Distribution.—Lesotho; South Africa: Eastern Cape, KwaZulu-Natal, Mpumalanga, Western Cape.

Discussion.—Outgroup comparisons with *Baetis* indicate that *Demoreptus* probably arose from a *Baetis*-like ancestor whose adults had hindwings with a costal process and whose larvae possessed a labium with relatively long glossae, paraglossae, and palp segments; relatively short, ventrally oriented legs with straight tarsi; well-developed hindwingpads; terga with scales and well-developed posterior marginal spines; marginally serrate gills; and a well-developed medial caudal filament. *Demoreptus* shows the following apomorphies: apicolaterally prolonged and attenuated fused incisors; relatively long, outstretched legs with twisted tarsi; loss of tergal scales; reduction of tergal posterior marginal spines; loss of marginal serrations in the gills; and reduction of the medial caudal filament.

Demoreptus is phenotypically somewhat similar to the Holarctic and Oriental genus *Acentrella* as redefined by Waltz and McCafferty (1987). Larvae of both genera lack tergal scales and marginal spines on the gills and have outstretched legs with twisted tarsi, reduced marginal spines on the abdominal terga, and a reduced medial caudal filament. However, larvae of *Demoreptus* have relatively long labial palps (especially with regard to segment 2) with segments that are well demarcated (Figs. 7,

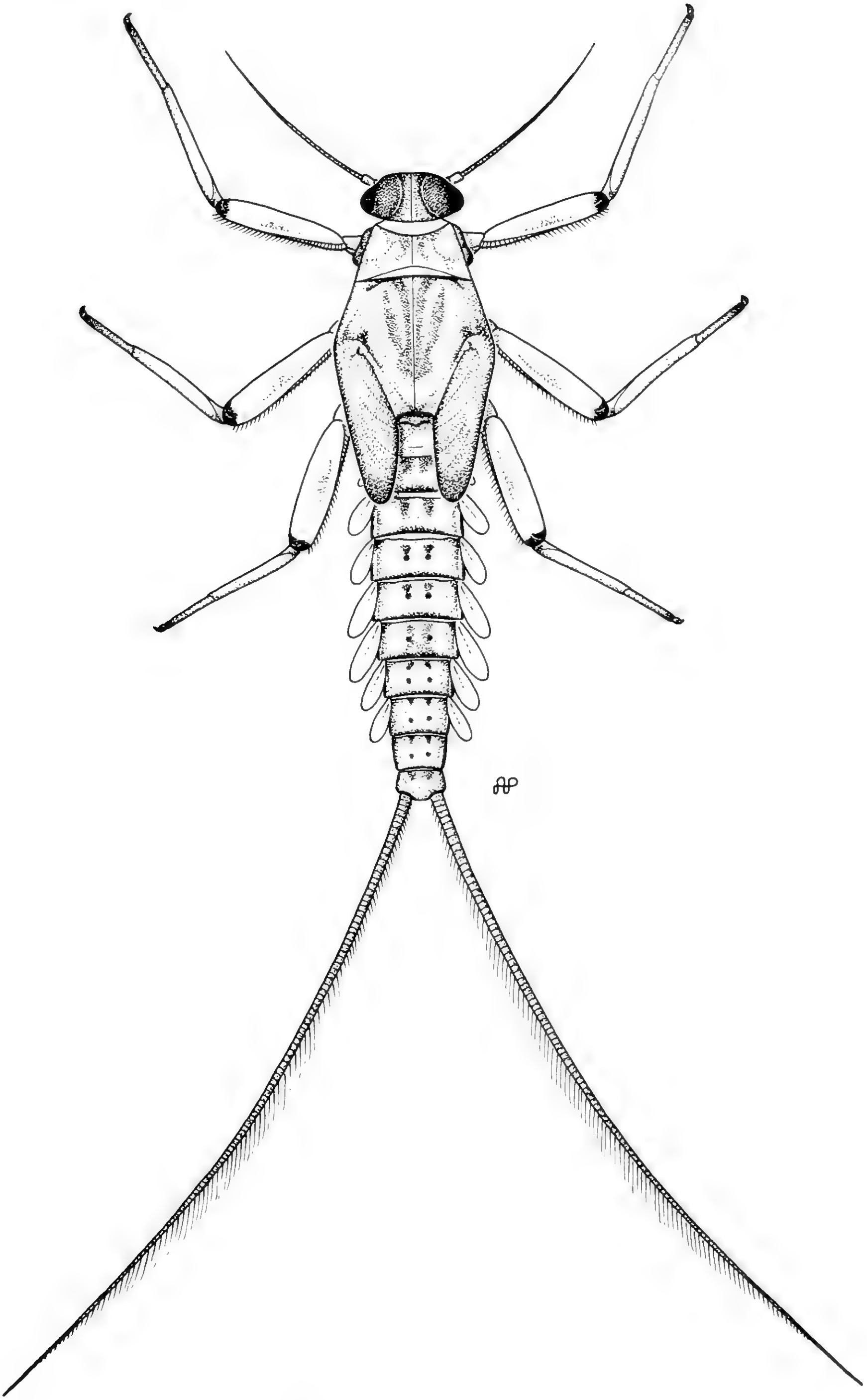
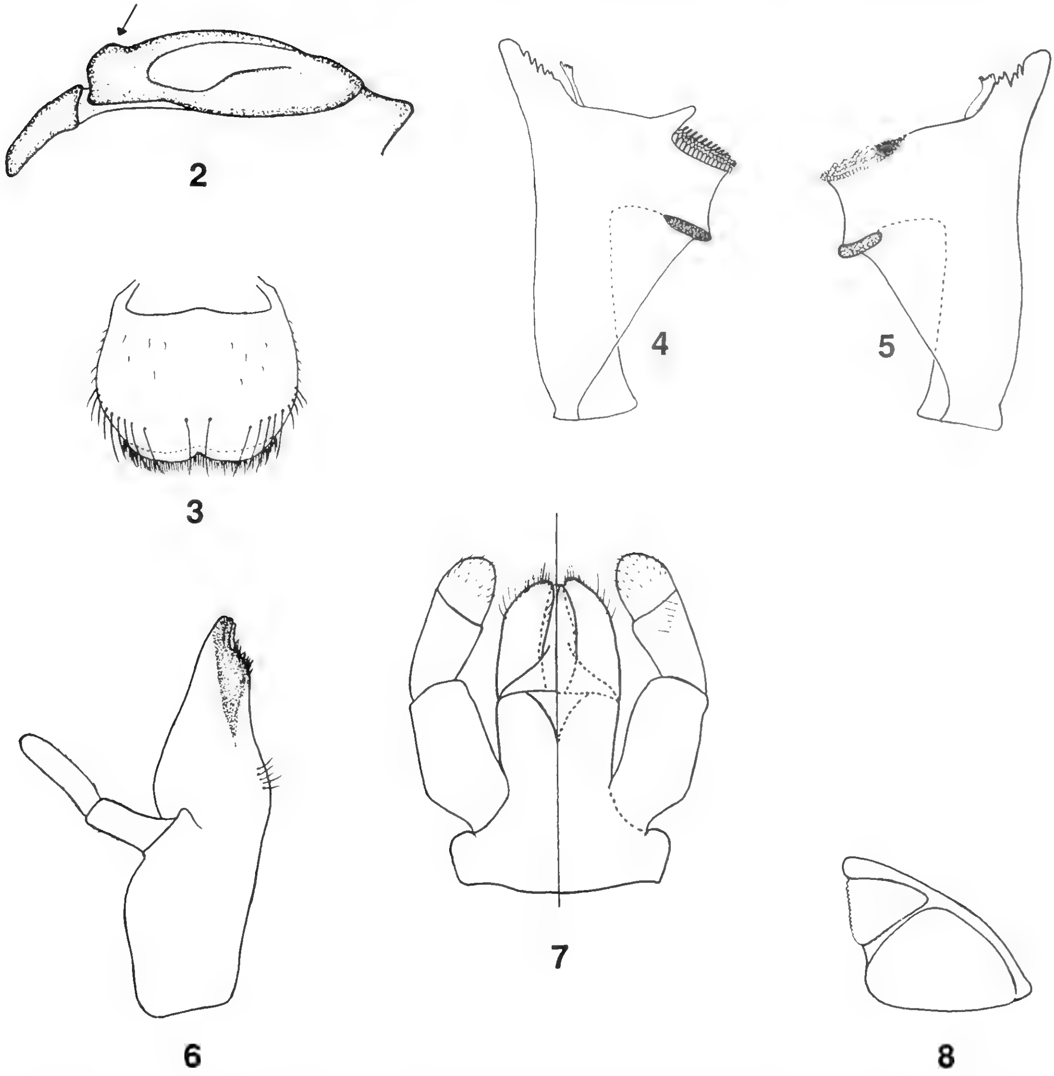


Fig. 1. *Demoreptus capensis,* larva (dorsal).



Figs. 2–8. *Demoreptus capensis*. 2, Mesoscutum (lateral; pointer towards process). 3, Labrum (dorsal). 4, Left mandible. 5, Right mandible. 6, Right maxilla. 7, Labium (left-ventral; right-dorsal). 8, Paraproct.

14, 21). More importantly, adults of *Demoreptus* have a small, rounded process anteriorly on the mesoscutum (Fig. 2) that is distinctly different from the apomorphically pointed, dorsally oriented process that adults of *Acentrella* and *Heterocloeon* have (Waltz 1994: Fig. 1). Adults of the poorly known Afrotropical genus *Tanzaniella* probably have that process (R. D. Waltz, pers. comm.), and it is possible that adults of the Oriental genus *Liebebiella* will also prove to have it once they are known (Waltz 1996). In any case, the presence of a pointed, dorsally oriented process appears to indicate a monophyletic grouping within the *Baetis* complex, and because *Demoreptus* lacks that process, it cannot be considered to belong in that grouping.

Larvae of *Demoreptus, Acentrella,* and certain other species of the *Baetis* complex, as well as distantly related genera such as the Afrotropical genus *Acanthiops* Waltz and McCafferty and the Panamerican genus *Baetodes* Needham and Murphy, show several convergent adaptations for sprawling and clinging on rocks in high gradient, fast-running streams. Those adaptations include long, outstretched legs, relatively small gills, and reduced medial caudal filament (see, e.g. Lugo-Ortiz and McCafferty 1996 and Barber-James and McCafferty (1997), and in some instances the taxa that have them look strikingly similar and may be easily confused, such as is the case with *Demoreptus* and *Acentrella.*

Demoreptus capensis (Barnard), **new combination**
(Figs. 1–8)

Acentrella capensis Barnard 1932: 259 (larva; male, female adults).
Baetis capensis (Barnard): Demoulin 1970: 66.

Larva (Fig. 1).—Body length: 6.5–7.0 mm; caudal filaments length: 3.8–4.0 mm. Head: Coloration yellow-brown, with no distinct pattern. Antennae 2.0× length of head capsule. Labrum (Fig. 3) nearly 1.22× wider than long, deeply cleft anteromedially, with submedial long, fine, simple seta and five to six long, fine, simple setae on either side of midline. Hypopharynx similar to Figure 17. Left mandible (Fig. 4) with six denticles; marginal lateral denticle enlarged. Right mandible (Fig. 5) with six denticles; marginal lateral denticle enlarged. Maxillae (Fig. 6) with four denticles on galealaciniae and five to six fine, simple setae on medial hump. Labium (Fig. 7) with glossae and paraglossae subequal in length; paraglossae somewhat broad; palp segment 1 as long as segments 2 and 3 combined; palps segment 2 with five to six fine, simple setae dorsally; palp segment 3 more or less apically rounded, not bulbous or clublike (width not exceeding that of apical width of segment 2). Thorax: Coloration yellow-brown, with irregular medium brown markings. Hindwingpads long, almost reaching hind margin of abdominal segment 1. Legs yellow-brown; femora with poorly developed villopore, row of long, robust, simple setae dorsally, and scattered short, stout and short, fine, simple setae ventrally; tibiae with row of short, fine, simple setae dorsally and scattered short, stout, and short, fine, simple setae ventrally; tarsi with scattered short, fine, simple setae dorsally and six to seven stout, simple setae increasing in length towards distal end ventrally; tarsal claws with 11–12 denticles, increasing in length and girth distally. Abdomen: Coloration yellow-brown, with medium and dark brown markings. Segment 1 yellow-brown; segments 2–6 yellow-brown, with pair of dark brown longitudinal submedial markings and dark brown hind margins; segments 7–9 with pair of oblique medium brown dashes anteriorly, pair of small specks in posterior half, and medium brown to dark brown hind margins; segment 10 yellow-brown, with diffuse markings. Sterna pale yellow-brown. Gills whitish, poorly tracheated. Paraprocts as in Figure 8. Caudal filaments cream to pale yellow.

Adult.—See description of Barnard (1932).

Material examined.—5 larvae, LESOTHO, Mokhotlong-Sengu, basin below Woolshed on Schonghong R, IX-25-1988, P. H. Skelton (AM); 2 larvae, LESOTHO, Sani-Linakeng Basin at road drift, tributary of Sani R, IX-24-1988, P. H. Skelton (AM); 3 larvae, SOUTH AFRICA, Eastern Cape, Waterkloof, III-27-1991, F. Weir (AM); 2 larvae, SOUTH AFRICA, KwaZulu-Natal, Highmoor Forest, Little Mooi R, 1800 m, IX-19-1990, W. P. and N. McCafferty (PERC); 2 larvae, SOUTH AFRICA, Western Cape, Jonkershoek Mnts., 2nd tributary of Eerste R, 1000 m, IX-28-1990, W. P. and N. McCafferty (PERC); 33 larvae, 1 ♀ adult, SOUTH AFRICA, Western Cape, Jonkershoek Mnts., Eerste R nr bridge at end of dirt rd, IX-28-1990, W. P. and N. McCafferty (PERC).

Discussion.—Larvae of *D. capensis* are distinguished from those of *D. natalensis* by the setation of the labrum (Fig. 3), the deeper and sharper denticulation of both mandibles (Figs. 4, 5), relatively short segment 2 and apically rounded segment 3 of the labial palps (Fig. 7), and long hindwingpads that almost reach the hind margin of abdominal segment 1. Adults of *D. capensis* are distinguished from those of *D. natalensis* by the presence of an acute costal process in the hindwings (Barnard 1932, 1940, Crass 1947).

Demoreptus monticola (Crass), **new combination**

(Figs. 9–15)

Acentrella monticola Crass 1947: 75 (larva; male, female adults).

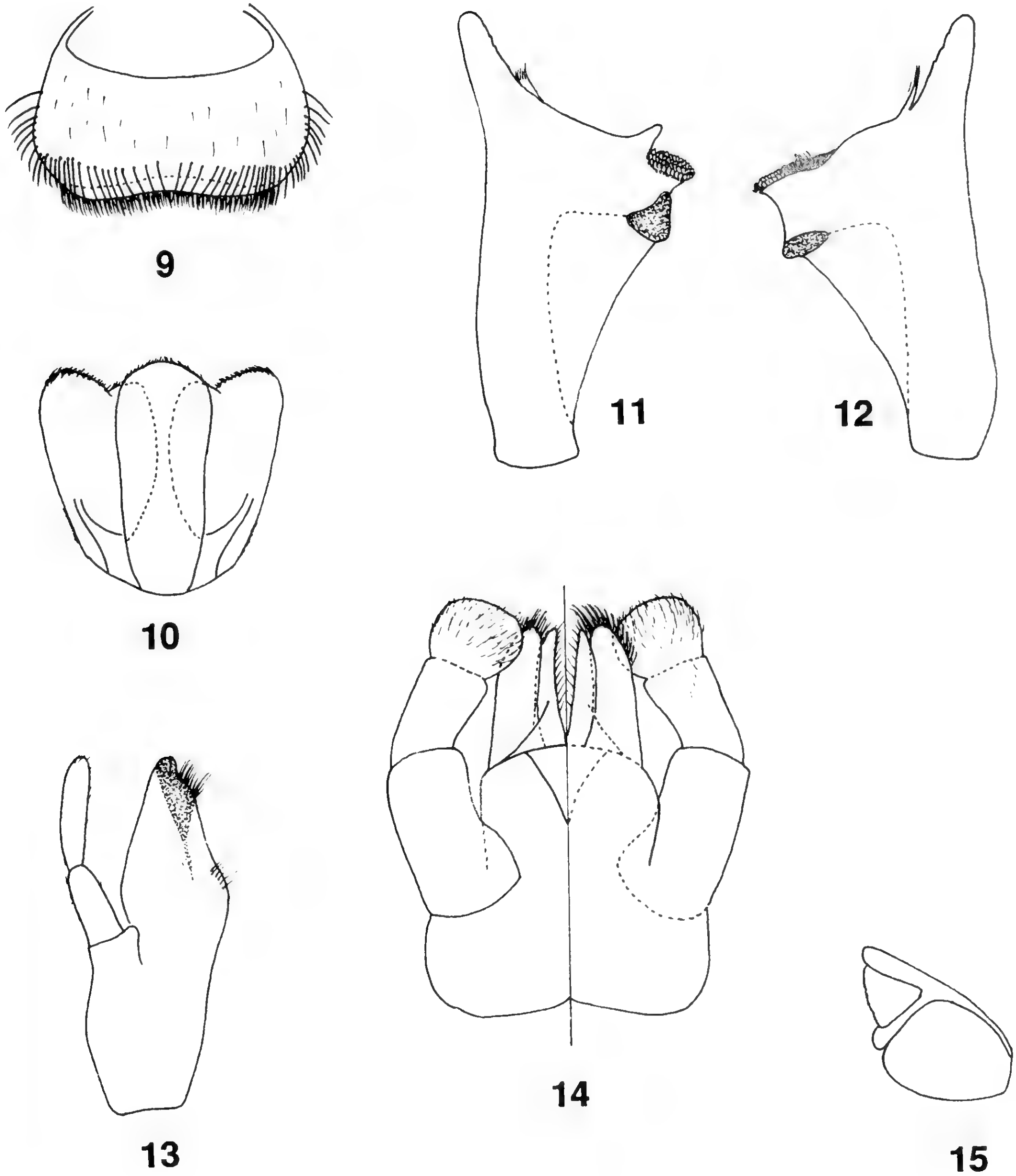
Baetis monticola (Crass): Demoulin 1970: 68.

Larva.—Body length: 6.5–6.8 mm; caudal filaments length: 5.8–6.0 mm. Head: Coloration yellow-brown, with vermiform medium brown markings on frons. Antenna 1.5× length of head capsule. Labrum (Fig. 9), 2.62× wider than long, with shallow anteromedial emargination and 18–20 long, fine, simple setae on either side of midline; submedial seta absent. Hypopharynx as in Figure 10. Left mandible (Fig. 11) with incisors fused into one bladelike structure lacking denticles; prostheca apically denticulate. Right mandible (Fig. 12) with incisors fused into bladelike structure lacking denticles; prostheca apically pointed, with long, fine, simple setae medially. Maxillae (Fig. 13) with four denticles on gealaciniae and six to seven fine, simple setae on medial hump. Labium (Fig. 14) with glossae and paraglossae somewhat slender and subequal in length; palp segment 1 subequal to segments 2 and 3 combined; palp segment 2 with three to four fine, simple setae dorsally; palp segment 3 bulbous, clublike (medially broader than apical width of segment 2). Thorax: Coloration yellow-brown, with irregular medium brown markings. Legs yellow-brown; femora with poorly developed villopore, row of long, robust, simple setae dorsally, and scattered short, stout and short, fine, simple setae ventrally; tibiae with scattered short, fine, simple setae dorsally and scattered short, stout, and short, fine, simple setae ventrally; tarsi with scattered short, fine, simple setae dorsally and six to seven stout, simple setae increasing in length towards distal end ventrally; tarsal claws with 11–12 denticles, increasing in length and girth distally. Abdomen: Coloration yellow-brown and dark brown. Segment 1 and 2 dark brown with large yellow-brown sublateral circular to oblong markings; segments 3–6 as segments 1 and 2, except with slender dorsal longitudinal medial yellow-brown streak; segments 7–9 yellow-brown, with submedial pair of dark brown specks in midregion and dark brown hind margins; segment 10 yellow-brown. Sterna cream to pale yellow-brown. Gills whitish, with single conspicuous tracheal trunk medially. Paraprocts as in Figure 15. Caudal filaments cream to pale yellow.

Adult.—See description of Crass (1947).

Material examined.—8 larvae, SOUTH AFRICA, Eastern Cape, Hogsback, Madonna and Child waterfall, X-7-1989 (AM); 142 larvae, SOUTH AFRICA, KwaZulu-Natal, Sani Pass Rd at police post, 1950 m, 16.4°C, X-1-1971, G. F. and C. H. Edmunds (PERC); 8 larvae, SOUTH AFRICA, KwaZulu-Natal, Umzimkulu R, between Underberg and Boesmansnek, 15.5°C, X-2-1971, G. F. and C. H. Edmunds (PERC); 5 larvae and ♀ subimago, SOUTH AFRICA, KwaZulu-Natal, Pietermaritzburg Nat. Bot. Garden, Dorspruit, IX-18-1990, W. P. and N. McCafferty (PERC); 31 larvae, SOUTH AFRICA, KwaZulu-Natal, Highmoor For., Little Mooi R, 1800 m, IX-19-1990, W. P. and N. McCafferty (PERC); 8 larvae, SOUTH AFRICA, Mpumalanga, 5 mi NE of Machadodorp, IX-22-1971, G. F. and C. H. Edmunds and H. J. Schoonbee (PERC).

Discussion.—Larvae of *C. monticola* are distinguished by the setation and shallow anterior emargination of the labrum (Fig. 9), adenticulate and bladelike mandibular incisors (Figs. 11, 12), and bul-



Figs. 9–15. *Demoreptus monticola*. 9, Labrum (dorsal). 10, Hypopharynx. 11, Left mandible. 12, Right mandible. 13, Right maxilla. 14, Labium (left-ventral; right-dorsal). 15, Paraproct.

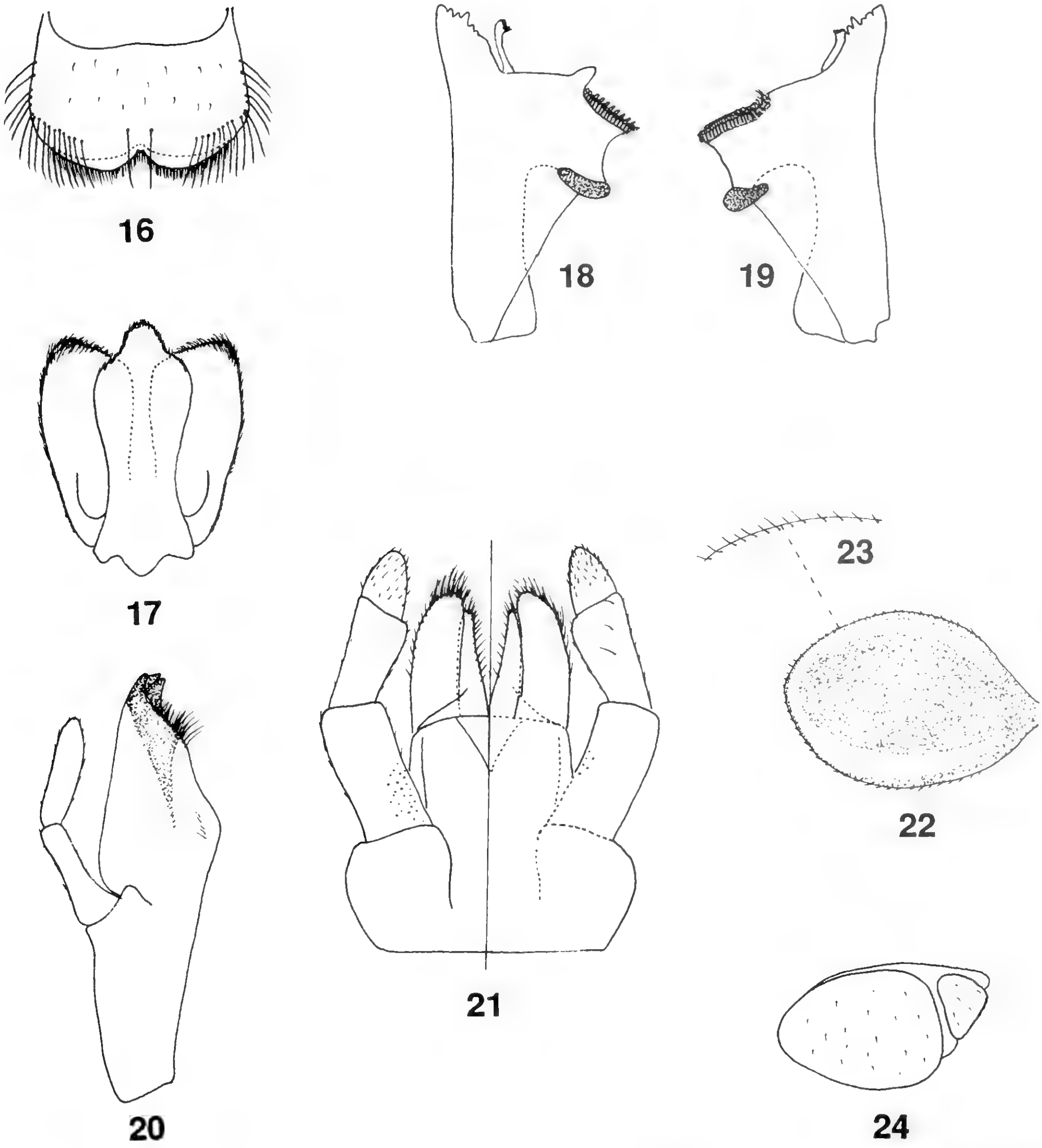
bous segment 3 of the labial palps (Fig. 14). Adults of *D monticola* differ from those of *D. capensis* in lacking an acute costal process in the hindwings, but evidently can only be told from those of *D. natalensis* by the presence of hindwings in both sexes (Crass 1947).

Demoreptus natalensis (Crass), **new combination**

(Figs. 16–24)

Acentrella natalensis Crass 1947: 72 (larva; male, female adults).

Baetis natalensis (Crass): Demoulin 1970: 68.



Figs. 16–24. *Demoreptus natalensis.* 16, Labrum (dorsal). 17, Hypopharynx. 18, Left mandible. 19, Right mandible. 20, Right maxilla. 21, Labium (left-ventral; right-dorsal). 22, Gill 4. 23, Detail of gill margin. 24, Paraproct.

Larva.—Body length: 4.8–5.1 mm; caudal filaments length: 4.8–5.1 mm. Head: Coloration dark brown, with vermiform yellow-brown markings on frons. Antennae as long as head capsule. Labrum (Fig. 16) nearly 1.81× wider than long, anteromedially deeply cleft, with submedial long, fine, simple seta and 10–11 long, fine, simple setae on either side of midline. Hypopharynx as in Figure 17. Left mandible (Fig. 18) with six denticles; marginal lateral denticle small. Right mandible (Fig. 19) with six denticles; marginal lateral denticles small. Maxillae (Fig. 20) with four denticles on galealaciniae and five to six fine, simple setae on medial hump. Labium (Fig. 21) with glossae subequal to paraglossae; paraglossae somewhat broad and long; palp segment 1 subequal to segments 2 and 3 combined; segment 2 with three to four fine, simple setae dorsally; palp segment 3 more or less pointed apically, not bulbous or clublike (width not exceeding that of apical width of segment 2). Thorax: Coloration dark brown, with irregular dark yellow-brown markings. Hindwingpads short, not more than 0.25× length of abdominal segment 1. Legs medium brown with irregular yellow-brown markings; femora with poorly developed villopore, row of long, robust, simple setae dorsally, and scattered short, stout and short, fine, simple setae ventrally; tibiae with row of short, fine, simple setae dorsally and scattered short, stout, and short, fine, simple setae ventrally; tarsi with row of short, fine, simple setae dorsally and eight to nine stout, simple setae increasing in length towards distal end ventrally; tarsal claws with 11–12 denticles, increasing in length and girth distally. Abdomen: Coloration dark brown to dark yellow-brown, with medium brown markings. Segment 1 dark yellow-brown, with dark brown anterior, posterior, and lateral margins; segment 2 dark brown, somewhat paler in midregion; segment 3 dark brown, with large sublateral dark yellow-brown quadrangles; segments 4 and 5 as segment 1, except with anterior submedial pair of small dark brown dashes; segments 6 and 7 as segment 1, except with submedial medium-sized dark brown circles in midregion; segments 8 and 9 as segments 6 and 7, except pale yellow-brown; segment 10 pale yellow-brown. Sterna pale yellow-brown to cream. Gills (Fig. 22) untracheated, dark yellow-brown to medium brown in midregion and whitish along margin; margin (Fig. 23) smooth and with fine, simple setae. Paraprocts as in Figure 24. Caudal filaments pale yellow-brown to cream.

Adult.—See description of Crass (1947).

Material examined.—7 larvae, LESOTHO, Schonghong R, Sangu-Orange Basin, Sani Rd bridge, IX-21-1988, P. H. Skelton (AM); 2 larvae, SOUTH AFRICA, Eastern Cape, Berg R, at Hwy N2, nr Grahamstown, XI-13-1990, W. P. and N. McCafferty (PERC); 4 larvae, SOUTH AFRICA, Eastern Cape, Hogsback, Buffalo R, Madonna and Child waterfall, X-7-1989 (AM); 62 larvae, SOUTH AFRICA, KwaZulu-Natal, Sani Pass Rd at police post, 1950 m, 16.4°C, X-1-1971, G. F. and C. H. Edmunds (PERC); 5 larvae, SOUTH AFRICA, KwaZulu-Natal, Howick Falls, Umgeni R, 2-X-71, G. F. and C. H. Edmunds (PERC); 18 larvae, SOUTH AFRICA, KwaZulu-Natal, Impendle, W fork of Furth R, 1450 m, IX-18-1990, W. P. and N. McCafferty (PERC); larva, SOUTH AFRICA, KwaZulu-Natal, Impendle, Furth R, 1250 m, IX-18-1990, W. P. and N. McCafferty (PERC); 2 larvae, SOUTH AFRICA, KwaZulu-Natal, Camberg Nat. Res., riffle in Mooi R, IX-19-1990, W. P. and N. McCafferty (PERC); 36 larvae, SOUTH AFRICA, KwaZulu-Natal, Krantzloof Nat. Res., Molweni stream nr Kloof, 16.4°C, G. F. and C. H. Edmunds, X-4-1971 (PERC); 11 larvae, SOUTH AFRICA, KwaZulu-Natal, Molweni R at Krantzloof Nat. Res., 978 m, nr Durban, IX-21-1990, W. P. and N. McCafferty (PERC); 21 larvae, SOUTH AFRICA, Mpumalanga, MacMac R, above MacMac Falls, nr. Graskop, 1820 m, W. P. and N. McCafferty (PERC); 3 larvae, SOUTH AFRICA, Mpumalanga, Long Tom St. For., upper Sabie R, X-26-1990, W. P. and N. McCafferty (PERC).

Discussion.—Larvae of *D. natalensis* are distinguished from those of *D. capensis* by the setation of the labrum (Fig. 16), small marginal incisors of the mandibles (Figs. 18, 19), the apically narrowly rounded labial palps (Fig. 21), and brown abdominal gills that are submarginally whitish (Fig. 22). Adults of *D. natalensis* can be separated from those of *D. capensis* by the absence of a costal process in the hindwings, and evidently can be separated from those of *D. monticola* by the absence of hindwings in its males (Crass 1947).

KEY TO THE LARVAE OF *DEMOREPTUS*

1. Labial palps segment 3 bulbous and clublike (medially broader than apical width of segment 2) (Fig. 14); labrum with shallow anteromedial emargination (Fig. 9); incisors of mandibles adenticulate and bladelike (Figs. 11, 12) . . . . *D. monticola*
– Labial palps segment 3 not bulbous, narrowly or broadly rounded apically (width not exceeding that of apical width of segment 2) (Figs. 7, 21); labrum anteromedially deeply cleft (Figs. 3, 16); incisors of mandibles with distinct denticulation (Figs. 4, 5, 18, 19) 2
2. Labial palps segment 3 narrowly rounded apically (Fig. 21); hindwingpads less than 0.25× length of abdominal segment 1; abdominal gills brown, submarginally whitish (Fig. 22) . . . . *D. natalensis*
– Labial palps segment 3 broadly rounded apically (Fig. 7); hindwingpads long, almost reaching hind margin of abdominal segment 1; abdominal gills whitish throughout . . *D. capensis*

INTERSPECIFIC RELATIONSHIPS

Using *Baetis* as our outgroup for cladistic analysis of species relationships within *Demoreptus,* we hypothesize that *D. capensis* is the most plesiotypic species, whereas *D. monticola* and *D. natalensis* represent sister species. Overall, however, *D. capensis* appears most similar to *D. natalensis*; both have anteriorly notched labra with a submedial pair of long, simple setae (Figs. 3, 16), denticulate mandibles (Figs. 4, 5, 18, 19), and well-demarcated labial palps with a segment 3 whose width does not exceed that of segment 2 (Figs. 7, 21). Those similarities, however, are based on symplesiomorphies, and therefore are not indicative of common ancestry between the two species. Furthermore, *D. monticola* is a highly evolved species and thus very distinctive. Nevertheless, we consider the loss of the costal process in the hindwings of *D. monticola* and *D. natalensis* (Crass 1947: Figs. 16b, 18b) a compelling synapomorphy indicative of the recent common ancestry of these species. *Demoreptus capensis* retains the plesiomorphic acute costal process (Barnard 1932: Fig. 12b) in the hindwings, similar to that seen in *Baetis* and most other baetines.

Because, phenotipically, *D. monticola* is the most distinct of the three species and *D. capensis* and *D. natalensis* are most similar to each other, it would be tempting to erect a separate genus for *D. monticola.* However, it is not cladistically allowable because a separate taxon for *D. capensis* and *D. natalensis* would be paraphyletic. This situation is similar to that among the species of *Acanthiops,* where *A. marlieri* (Demoulin), being highly evolved, shows an extreme expression of clinal characters that may lead incorrectly to interpret it as a separate clade (see Barber-James and McCafferty 1997).

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A NEW SPECIES OF MEALYBUG IN THE GENUS *DYSMICOCCUS* (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE) OF IMPORTANCE IN HIGHBUSH BLUEBERRIES (*VACCINIUM CORYMBOSUM,* ERICACEAE) IN THE EASTERN UNITED STATES

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Abstract.—A new species of mealybug, ***Dysmicoccus vaccinii* Miller and Polavarapu**, is described that is believed to be a pest of highbush blueberries, *Vaccinium corymbosum* L. It has an unusual life history since most instars can be found in the field throughout the year, including January and February. The four female instars and five male instars are described and illustrated, including apterous and macropterous adult males. The blueberry mealybug is suggested as a common name. **New synonymy** is included as follows: *Dysmicoccus bispinosus* Beardsley is considered to be a junior synonym of *D. texensis* (Tinsley).

Key Words: Mealybugs, Coccoidea, Pseudococcidae, pest, blueberry, *Vaccinium,* roots, ants, *Acanthomyops, Lasius,* mutualism

Infestations of an undescribed species of mealybug belonging to the genus *Dysmicoccus* were discovered several years ago on the roots of highbush blueberries (*Vaccinium corymbosum* L.) in southern New Jersey. This genus encompasses more than 100 species (Ben-Dov 1994) including several major pests such as the gray sugarcane mealybug, *D. boninsis* (Kuwana) and the pineapple mealybug, *D. brevipes* (Cockerell).

The infestations n New Jersey are becoming increasingly prevalent especially in the light sandy-loam soils of Atlantic County. Although the impact of the mealybug on blueberry production and fruit quality has not been quantified, severe infestations appear to reduce vigor and lead to stunting of young plants. Circumstantial evidence has implicated this species as a vector of the Red ringspot virus (belonging to the Caulimovirus group of viruses), the causal agent of the Red ringspot disease in blueberries (Ramsdell et al. 1987). Red ringspot is one of the most important viral diseases of blueberries in New Jersey and also occurs in Arkansas, Connecticut, Massachusetts, Michigan, New York, North Carolina and Oregon (Ramsdell et al. 1987).

The purpose of this research is 1) to name this species and describe its morphological characters so that it can be differentiated from similar species, 2) to provide preliminary information on the biology of the species, and 3) to incorporate it in a key to adult females of *Dysmicoccus* so that the new species can be accurately identified.

In order to describe the new species and compare it with the most similar species, it is necessary to make the following nomenclatural changes effecting the status of *Dysmicoccus bispinosus* Beardsley and *D. tex-*

ensis (Tinsley). DRM has examined type specimens of these species and concludes that they belong to only one species (**new synonymy**). Since *D. texensis* was described by Tinsley in 1900 and *D. bispinosus* was described by Beardsley in 1965, by the law of priority the correct name of the species is *Dysmicoccus texensis.* Since type material of *Pseudococcus texensis* is a syntype series, we have selected as **lectotype** the left adult female specimen mounted on a slide with 1 other adult female with the left label "*Dactylopius/ texensis* (Tinsley)/Type/on *Acacia/ farnesiana/* San Diego, Texas/ E. A. Schwarz coll./ Dec. 1895 1899"; the right label contains a map giving the location of the lectotype and states "*Pseudococcus/ texensis* /LECTOTYPE/ PARALECTOTYPE/ ." In addition to the lectotype there are 28 adult female paralectotypes on 6 slides; all specimens are in the USNM.

METHODS

To determine the percent of the mealybug population in different stages at various times of the year, 1–2 infested blueberry plants were collected at approximately 1–2 month intervals from an infested blueberry field in Hammonton, New Jersey. Plants were gently uprooted with minimal disturbance to the root system. Each plant along with the surrounding soil were placed in a 30-gal plastic bag for further examination. In the laboratory, the root-system and the accompanying soil from each plant sample were carefully examined for different mealybug stages. This sampling procedure may be biased against the minute, early instar nymphal stages, but should nevertheless provide a qualitative measure of the occurrence of various stages of the insect. Mealybug samples were preserved in 70% alcohol and shipped to the Systematic Entomology Laboratory (SEL) for identification of different stages of the insect.

Terminology in the descriptions follows that of Williams and Granara de Willink (1992) and Gimpel and Miller (1996) for adult females and immatures and that of Afifi (1968) for adult males. Measurements and numbers are from 10 specimens when available, and are given as an average followed by the range in parentheses. Enlargements on illustrations are not proportional. Depositories of specimens are: The Natural History Museum, London (BMNH); California Department of Food and Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); Muséum National d'Histoire Naturelle, Paris (MNHN); University of California, Davis (UCD); National Museum of Natural History, Beltsville, MD (USNM).

RESULTS

Dysmicoccus vaccinii Miller and Polavarapu, new species

Suggested Common Name: Blueberry mealybug

Type data.—The adult female holotype is mounted alone on a slide with the left label "NEW JERSEY/ Hammonton, Variety/ Farms, Atlantic Co.,/ 17-XI-1994/ ex. Blueberry/ S. Polavarapu" right label "*Dysmicoccus/ vaccinii/* Miller and Polavarapu/ HOLOTYPE" . This slide is deposited in the USNM. In addition there are 1,354 paratypes on 185 slides that are deposited in BMNH, CDA, FSCA, MNHN, UCD, USNM.

Etymology.—The species epithet is the genitive form of the blueberry host genus *Vaccinium.*

ADULT FEMALE
(Fig. 1)

Slide-mounted characters.—Holotype oval, length 1.9 mm, width 1.1 mm. Paratypes 1.7(1.4–1.9) mm long, 1.1(0.8–1.2) mm wide.

Dorsum with 17 pairs of cerarii, cerarian formula as follows: Left side 1–6(2), 7(3), 8–11(2), 12(3), 13–14(2), 15(3), 16(2), 17(4); paratypes with cerarius 1 with 2 conical setae, cerarius 2 with 2(2–3) conical setae, cerarius 3 with 2(1–2) conical setae, cerarius 4 with 2(2–3) conical setae, cerarius 5 with 2(1–3) conical setae, cerarius 6 with 2(1–2) conical setae, cerarius 7 with 2(2–3) conical setae, cerarius 8 with 2(1–3) conical setae, cerarius 9 with 2(1–3) conical setae, cerarius 10 with 3(2–3) conical setae, cerarius 11 with 2(1–3) conical setae, cerarius 12 with 3(3–4) conical setae, cerarius 13 with 2(1–3) conical setae, cerarius 14 with 2(2–3) conical setae, cerarius 15 with 3(2–5) conical setae, cerarius 16 with 5(3–7) conical setae, cerarius 17 with 4(3–5) conical setae. Cerarius 12 with 3 auxiliary setae (paratypes with 3(1–5) setae), 24 trilocular pores (paratypes with 23(17–27) pores), and 5 discoidal pores (paratypes with 3(1–5) pores). Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores about equal to diameter of trilocular pore. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 27 μ long (paratypes 30(22–37) μ); 6 submedial setae on segment VIII (paratypes 6(5–6) setae), longest seta 30 μ long (paratypes 34(25–42) μ).

Anal ring seta 116 μ long (paratypes 117(101–143) μ); 1.4 times as long as greatest diameter of ring (paratypes 1.4(1.3–1.6) times).

Venter with multilocular pores in posterior and anterior bands on segments VI–VIII, in posterior band on segment V (paratypes sometimes with 1 or 2 pores near anterior margin of segment V and near posterior margin of segment IV), without pores on thorax (1 of 10 paratypes with 1 pore on prothorax near anterior leg). Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1 discoidal pore near eye on 1 side of body, absent near other eye (paratypes with 1(0–2) pores near each eye. Oral-collar tubular ducts of 1 size, present near marginal and submarginal areas of abdomen and near setal bases in medial and submedial areas of abdomen and thorax, 1 oral collar mesad of cerarius 12 (paratypes 2(0–5) ducts), without oral collars in marginal or submarginal areas of thorax or head. Setae as follows: 6 cisanal, (paratypes 4(3–6), longest 42 μ long (paratypes 44(37–49) μ); longest anal-lobe seta 148 μ long (paratypes 157(124–168) μ); longest seta on trochanter 111 μ long (paratypes 109(99–124) μ).

Circulus 96 μ wide (paratypes 90(74–104) μ), divided by intersegmental fold. Labium 161 μ long (paratypes 170(161–180) μ). Antennae 8-segmented, (paratypes rarely 7-segmented) 353 μ long (paratypes 341(316–366) μ). Legs with 33 translucent pores on hind femur (paratypes 29(15–52) pores); 21 pores on hind tibia (paratypes 24(8–37) pores). Femur 212 μ long (paratypes 210(185–235) μ); tibia 198 μ long (paratypes 190(170–217) μ); tarsus 91 μ long (paratypes 99(91–101) μ). Tibia/tarsus 2.2 (paratypes 2.0(1.8–2.3)); femur/tibia 1.1 (paratypes 1.1(1.1–1.2)). Hind tibia with 19 setae (paratypes 19(16–23) setae). Length of hind femur divided by greatest width of femur 3.1(2.9–3.4). Claw digitules on hind 2 pairs of legs clubbed, each claw with 1 digitule with club slightly larger than club on other digitule; claw digitules of front pair of legs clubbed, about equal in size. Tarsal digitules on hind 2 pairs of legs apically clubbed, each tarsus with 1 digitule with club noticeably larger than club on other digitule; tarsal digitules on front pair of legs of 2 different sizes and shapes, 1 digitule on each tarsus clubbed and nearly reaching tip of claw, other digitule short and apically acute.

Notes.—The above description is based on 733 specimens from 4 localities. Adult females can be distinguished from all other instars by having multilocular pores, translucent pores on the hind femur and tibia, and a vulva.

THIRD-INSTAR FEMALE
(Fig. 2)

Slide-mounted characters.—Body oval, 1.2(1.0–1.4) mm long, 0.8(0.6–0.9) mm wide.

Dorsum with 17 pairs of cerarii, cerarii 1 and 2 with 2 conical setae, cerarii 3 and 4 with 2(1–2) conical setae, cerarius 5 with 2

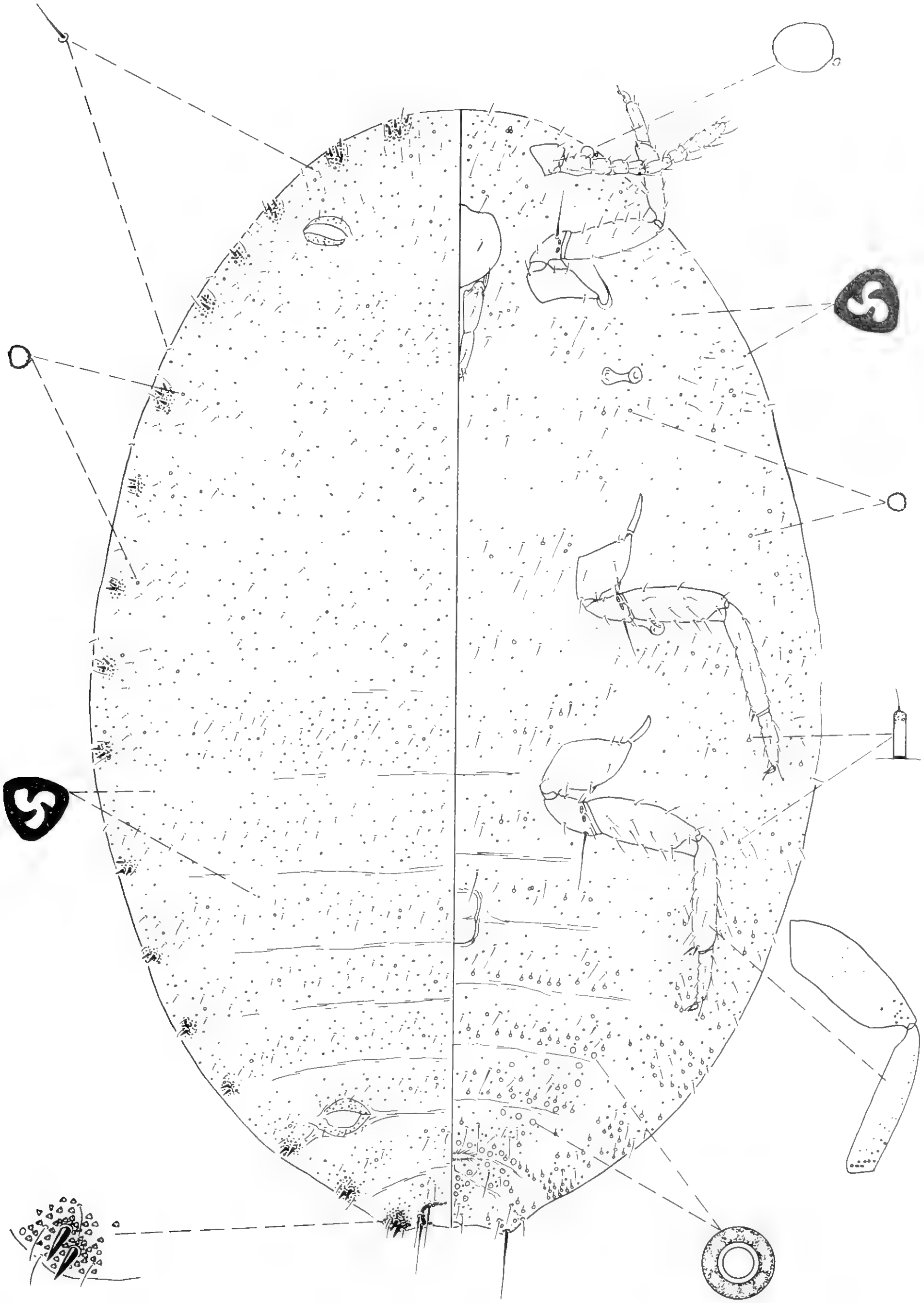

Fig. 1. Adult female *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-17-1994, on *Vaccinium corymbosum,* S. Polavarapu.

conical setae, cerarius 6 with 2(0–2) conical setae, cerarius 7 with 2 conical setae, cerarius 8 with 2(0–2) conical setae, cerarius 9 with 2(1–2) conical setae, cerarius 10 with 2(0–3) conical setae, cerarius 11 with 2(1–2) conical setae, cerarius 12 with 3(2–3) conical setae, cerarius 13 with 2(1–2) conical setae, cerarius 14 with 2(1–3) conical setae, cerarius 15 with 3(2–3) conical setae, cerarius 16 with 4(3–4) conical setae, cerarius 17 with 3(3–4) conical setae. Cerarius 12 with 1(0–3) auxiliary setae, 10(7–14) trilocular pores, and 1(1–2) discoidal pores. Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores about equal to diameter of trilocular pore. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 24(19–28) μ long; 3(3–4) submedial setae on segment VIII, longest seta 25(20–28) μ long.

Anal ring seta 93(86–101) μ long; 1.5(1.4–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–2) pores near each eye. Normally with 1 oral-collar tubular duct in cluster of setae posterior of each spiracle; oral collars absent elsewhere. Setae as follows: 4 cisanal setae, longest 31(25–37) μ long; longest anal-lobe seta 125(111–138) μ long; longest seta on trochanter 71(54–82) μ long.

Circulus 62(49–74) μ wide, divided by intersegmental fold. Labium 131(122–136) μ long. Antennae 6- or 7-segmented, 244(230–259) μ long. Legs without translucent pores. Femur 136(131–143) μ long; tibia 105(96–109) μ long; tarsus 89(84–95) μ long. Tibia/tarsus 1.2(1.1–1.2); femur/tibia 1.3(1.2–1.4). Hind tibia with 10(8–11) setae. Length of hind femur divided by greatest width of femur 2.4(2.3–2.7). Claw and tarsal digitules same as in adult female.

Notes.—This description is based on 313 specimens from 3 localities. The third-instar female can be distiguished from all other instars by having each cerarius with conical setae, antennae usually 7-segmented, rarely 6, hind tibia length divided by hind tarsus length 1.1 to 1.2, usually 1.2, and cerarius 12 with 7–14 associated trilocular pores. It is most similar to the second-instar female which differs by having cerarii anterior of cerarius 7 without conical setae (cerarian setae are filamentous), antennae usually 6-segmented, hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores.

SECOND-INSTAR FEMALE
(Fig. 3)

Slide-mounted characters.—Oval, 0.9(0.8–1.0) mm long, 0.5(0.5–0.6) mm wide.

Dorsum with 17 pairs of cerarii, posterior cerarii to cerarius 7 or 8 usually with at least 1 conical seta and 1 filamentous seta, cerarii 1–6 with 2 setae, cerarii 7–9 with 2(1–2) setae, cerarius 10 with 2(1–3) setae, cerarius 11 with 2(1–2) setae, cerarius 12 with 3(2–3) setae, cerarius 13 with 2(1–2) setae, cerarius 14 with 2(1–2) setae, cerarius 15 with 3(2–3) setae, cerarius 16 with 2(1–2) setae, cerarius 17 with 3(3–4) setae. Cerarius 12 with 3(2–5) trilocular pores, and 1(0–1) discoidal pores. Multilocular pores absent; trilocular pores scattered over surface; discoidal pores about equal to diameter of trilocular pores. Oral-collar-tubular ducts absent. Longest submedial seta on segment VII 17(15–22) μ long; 1(0–2) submedial setae on segment VIII, longest seta 14(12–16) μ long.

Anal ring seta 66(57–79) μ long; 1.5(1.3–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–2) pores near each eye. Without oral-collar tubular ducts. Setae as follows: 4 cisanal setae, longest 23(17–27) μ long; longest anal-lobe seta 93(84–99) μ long; longest seta on trochanter 71(54–82) μ long.

Circulus 44(35–52) μ wide, divided by

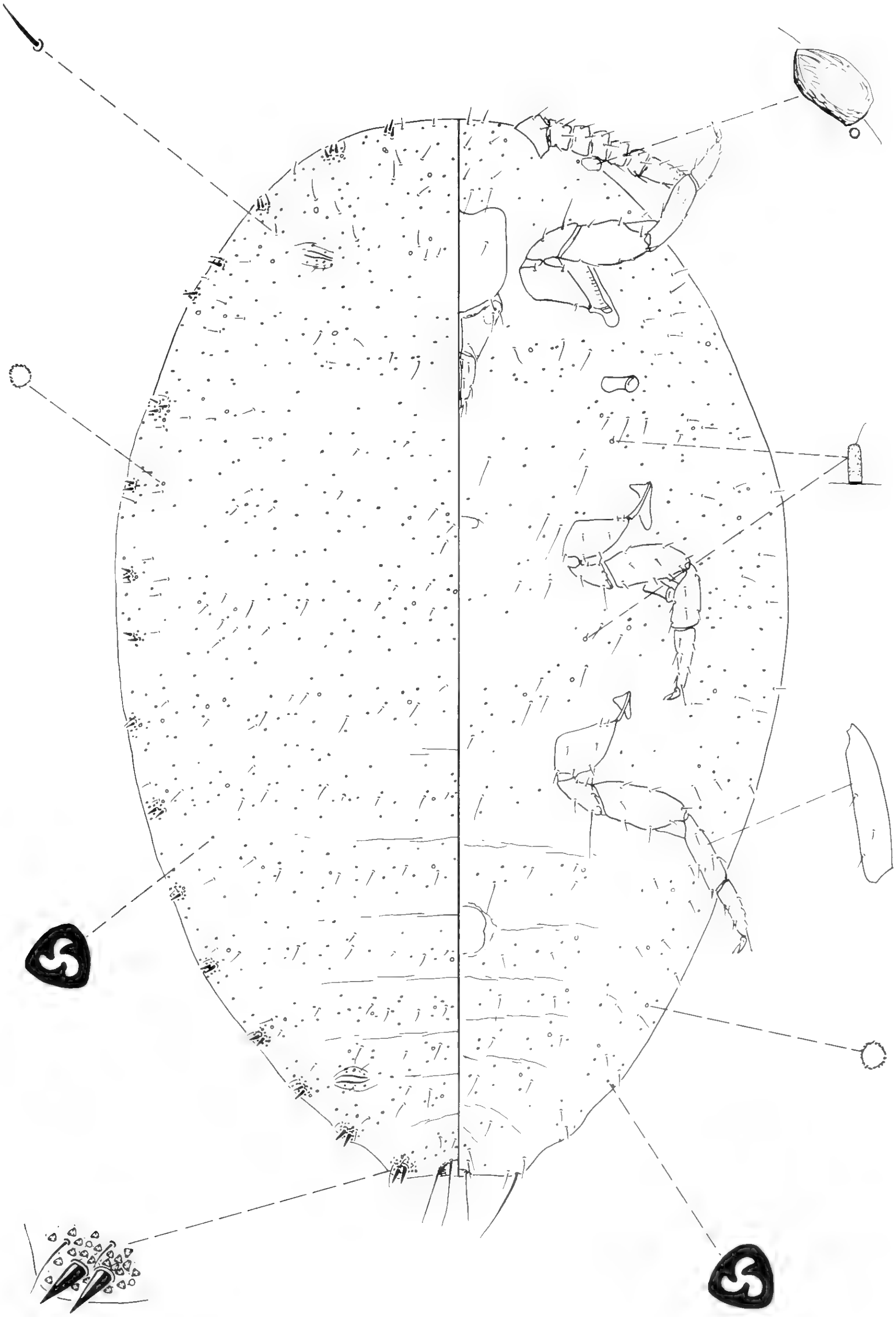

Fig. 2. Third-instar female *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller.

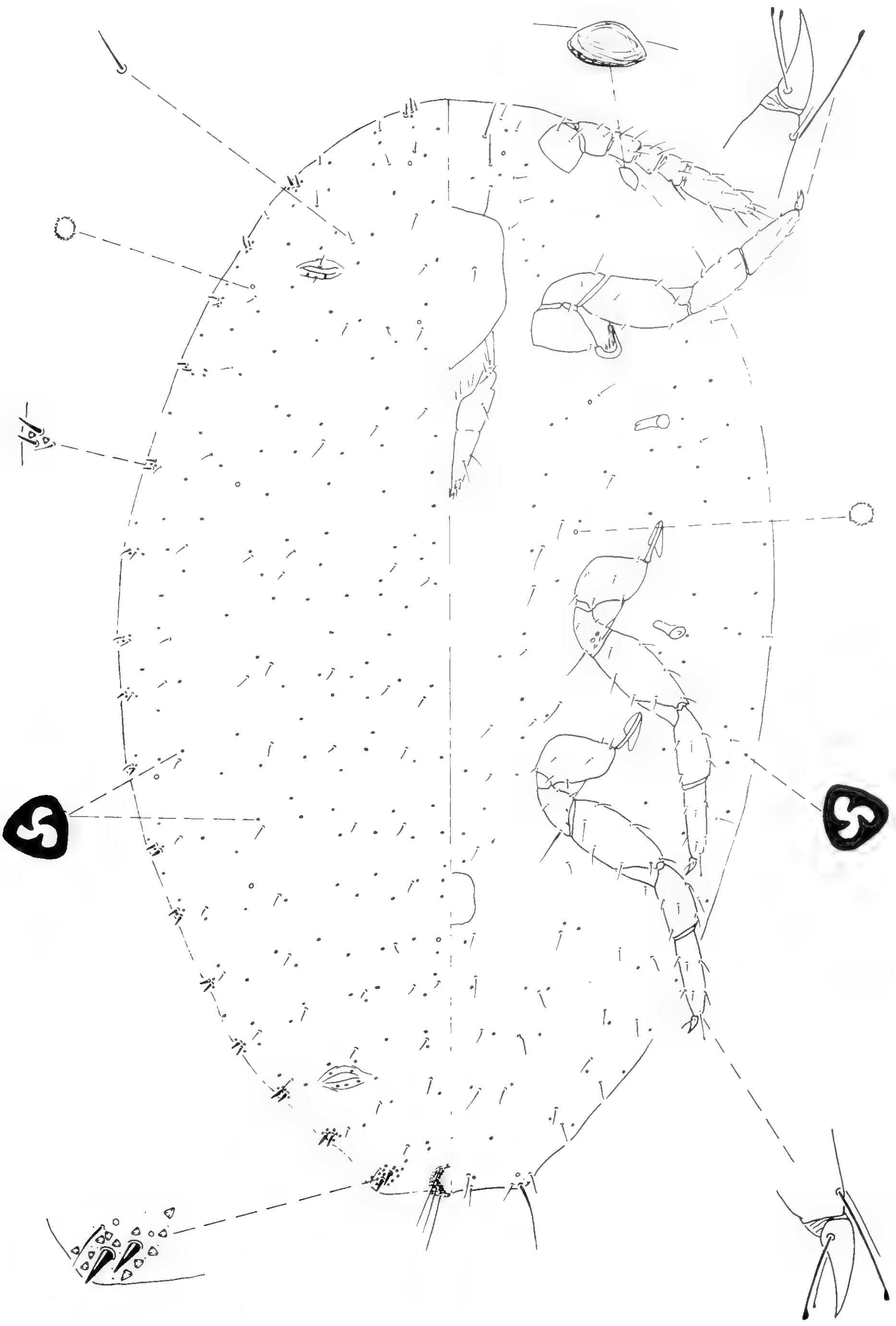

Fig. 3. Second-instar female *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller.

intersegmental fold. Labium 99(94–104) μ long. Antennae 6-segmented, 244(230–259) μ long. Legs without translucent pores. Femur 91(86–99) μ long; tibia 67(62–73) μ long; tarsus 74(69–79) μ long. Tibia/tarsus 0.9; femur/tibia 1.4(1.3–1.4). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.2(2.0–2.4). Claw digitules same as on adult female. Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same as other legs except apically acute digitule is very short.

Notes.—This description is based on 78 specimens from 3 localities. The second-instar female can be distiguished from all other instars by having antennae usually 6-segmented, hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores. It is most similar to the second-instar male which differs by having oral-collar tubular ducts; these are absent on the second-instar female.

FIRST INSTAR
(Fig. 4)

Slide-mounted characters.—Oval, 0.6(0.5–0.7) mm long, 0.3(0.3–0.4) mm wide.

Dorsum with 16 pairs of definite cerarii, anterior cerarius indefinite, posterior cerarii to cerarius 2, 3, or 4 with at least 1 conical seta and 1 filamentous seta, cerarii 1–9 with 2 setae, cerarius 10–16 with 2(1–2) setae, cerarius 17 indefinite, represented by 1 or more unassociated setae. Cerarius 12 with 1 trilocular pore. Multilocular and discoidal pores absent; trilocular pores arranged in 4 longitudinal lines on each side of body. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 10(8–11) μ long; without submedial setae on segment VIII.

Anal ring seta 52(47–54) μ long; 1.7(1.6–1.9) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores arranged in 1 mediolateral longitudinal line on each side of abdomen, more abundant on thorax and head. Discoidal pores associated with base of sublateral line of setae, also with 1 associated with each spiracle, with 1(0–1) pore near each eye. Without oral-collar tubular ducts. Setae as follows: 4 cisanal setae, longest 18(16–22) μ long; longest anal-lobe seta 50(42–61) μ long; longest seta on trochanter 39(32–44) μ long.

Inner circle of circulus 30(27–35) μ wide, divided by intersegmental fold. Labium 76(64–83) μ long. Antennae 6-segmented, 142(128–158) μ long. Legs without translucent pores. Femur 63(59–68) μ long; tibia 46(42–49) μ long; tarsus 60(56–65) μ long. Tibia/tarsus 0.8(0.7–0.8); femur/tibia 1.4(1.3–1.5). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.1(1.9–2.3). Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same as other legs except apically acute digitule is very short.

Notes.—This description is based on 70 specimens from 3 localities. The first instar can be distiguished from all other instars by having 6-segmented antennae, hind tibia length divided by hind tarsus length 0.7–0.8, usually 0.8, and cerarius 12 with 1 associated trilocular pore. It is most similar to the second-instar female which differs by having hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores.

SECOND-INSTAR MALE
(Fig. 5)

Slide-mounted characters.—Body oval, 0.9(0.8–1.0) mm long, 0.6(0.5–0.6) mm wide.

Dorsum with 17 pairs of cerarii, posterior cerarii to cerarius 4 or 5 usually with at least 1 conical seta and 1 filamentous seta, cerarii 1–7 with 2 setae, cerarii 8 and 9 with 2(1–2) setae, cerarius 10 with 2(1–2) setae, cerarius 11 with 2 setae, cerarius 12 with 2(1–3) setae, cerarius 13 with 2(1–2) setae,

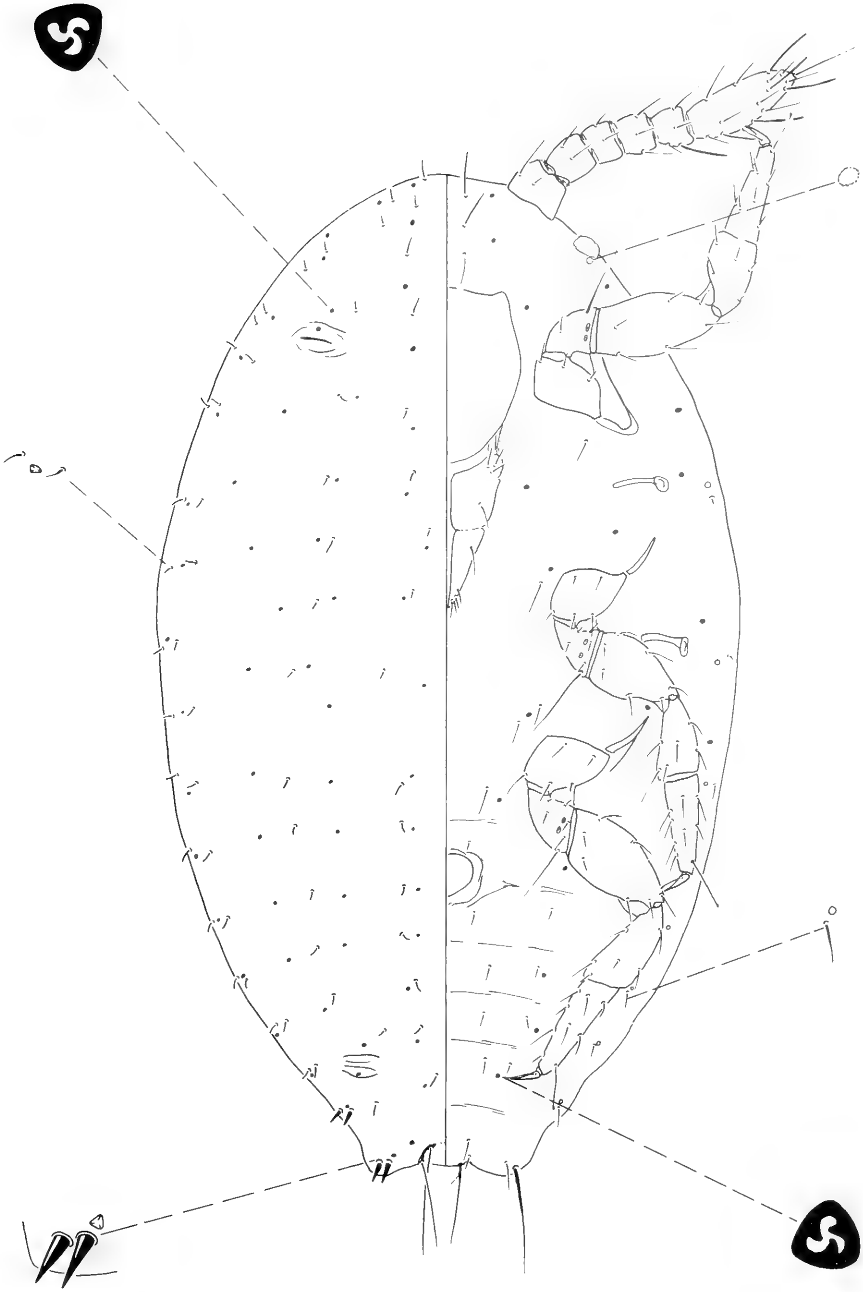

Fig. 4. First-instar (sex undetermined) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller.

cerarius 14 with 2(1–2) setae, cerarius 15 with 2(1–3) setae, cerarius 16 with 2(2–3) setae, cerarius 17 with 3(2–3) setae. Cerarius 12 with 2(1–3) trilocular pores, and 0(0–1) discoidal pores. Multilocular pores absent; trilocular pores scattered over surface; discoidal pores about equal to diameter of trilocular pores. Oral-collar tubular ducts of 1 size, same as large size on venter, present in rows across segments beginning on segment V or VI forward to head. Longest submedial seta on segment VII 16(12–19) μ long; 1(1–2) submedial setae on segment VIII, longest seta 14(10–20) μ long.

Anal ring seta 69(57–77) μ long; 1.5(1.3–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–1) pores near each eye. With 2 sizes of oral-collar tubular ducts, larger size present in margin or submargin from segments VII or VI forward to head; smaller size in rows on segments VII and VI and occasionally on segment V, also present in medial and submedial areas of anterior abdominal segments, thorax, and head. Setae as follows: 4 cisanal setae, longest 23(19–32) μ long; longest anal-lobe seta 92(86–106) μ long; longest seta on trochanter 53(42–59) μ long.

Circulus 38(35–42) μ wide, divided by intersegmental fold. Labium 95(91–99) μ long. Antennae 6-segmented, 177(153–191) μ long. Legs without translucent pores. Femur 87(79–94) μ long; tibia 66(56–69) μ long; tarsus 67(63–69) μ long. Tibia/tarsus 1.0(0.9–1.0); femur/tibia 1.3(1.3–1.4). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.3(2.1–2.4). Claw digitules same as on adult female. Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same dimensions as other legs except apically acute digitule is very short.

Notes.—This description is based on 109 specimens from 3 localities. The second-instar male can be distiguished from all other instars by having dorsal oral-collar tubular ducts, mouthparts, and no vulva.

THIRD-INSTAR MALE (PREPUPA)
(Fig. 6)

Slide-mounted characters.—Body elongate, 0.9 mm long, 0.4 mm wide.

Dorsum without cerarii, posterolateral margins of segments VI, VII, and VIII each with 2 setae conspicuously longer than remaining setae on segments. Multilocular pores scattered over surface except on mesothorax and abdominal segments VIII and IX; trilocular pores absent; discoidal pores associated with multilocular pores and oral collars. Oral-collar tubular ducts of 1 size, scattered over surface except on mesothorax and abdominal segments VIII and IX. Longest submedial seta on segment VII 17 μ long; 3 submedial setae on segment VIII, longest seta 15 μ long.

Anal ring without setae and pores.

Venter with multilocular pores scattered over surface except segments VIII and IX. Trilocular pores absent. Discoidal pores associated with multiloculars and oral collars. With oral-collar tubular ducts in marginal areas except on abdominal segments VIII and IX.

Circulus 82μ wide, divided by intersegmental fold. Mouth structure weakly indicated.Antennal segments indistinct, 232μ long. Legs without translucent pores. Femur 91μ long; division between tibia and tarsus indistinct, tibia+tarsus 148μ long. Wing buds of mesothoracic wings protruding from lateral margin, about 110μ long. Wing buds of hamulohalterae absent.

Notes.—The above description is based on 1 specimen reared in the Laboratory that originally was collected in Hammonton, New Jersey on *Vaccinium corymbosum,* March 19, 1996. Preserved June 6, 1996. A second specimen, field collected from the same locality and host on September 28, 1996, lacks all signs of wing buds and has a very weak indication of the circulus. We suspect that this specimen is a prepupa of the apterous male. The prepupa can be distiguished from all other instars by having, multilocular pores, oral-collar tubular ducts, antennae without definite segmentation, tibia and tarsus fused, no mouthparts, no aedeagus, no definite constriction for the head. It is most similar to the pupa which differs by having antennae 10-segmented and a definite constriction for head.

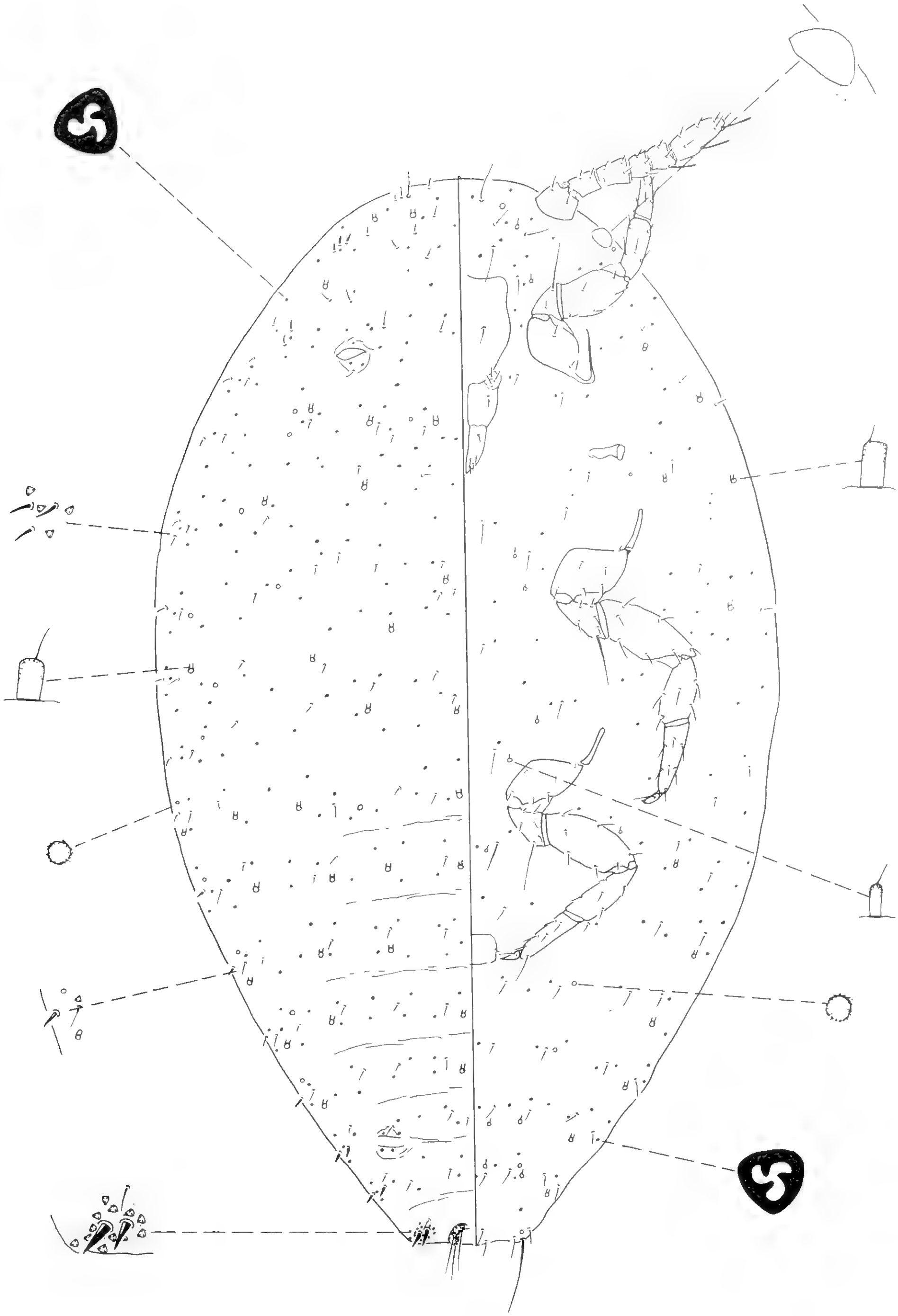

Fig. 5. Second-instar male *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller.

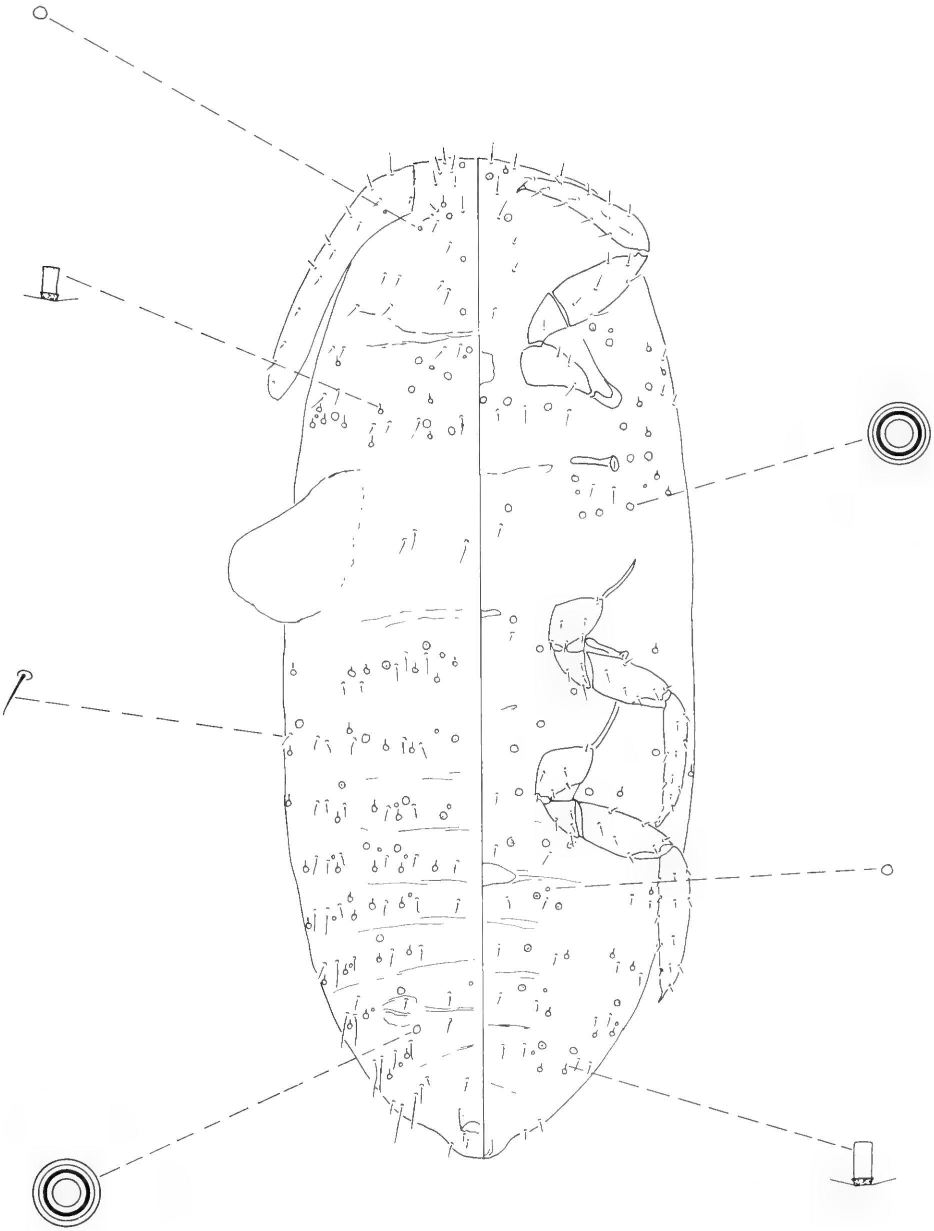

Fig. 6. Third-instar male (prepupa) *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

FOURTH-INSTAR MALE (PUPA)
(Fig. 7)

Slide-mounted characters.—Body elongate, 1.0(0.9–1.1)mm long, 0.4(0.3–0.4)mm wide.Dorsum without cerarii, setae on posterolateral margins of segments VI, VII, and VIII each with 2 setae conspicuously longer than remaining setae on segements. Multilocular pores present in mediolateral areas of head, thorax, and abdo-

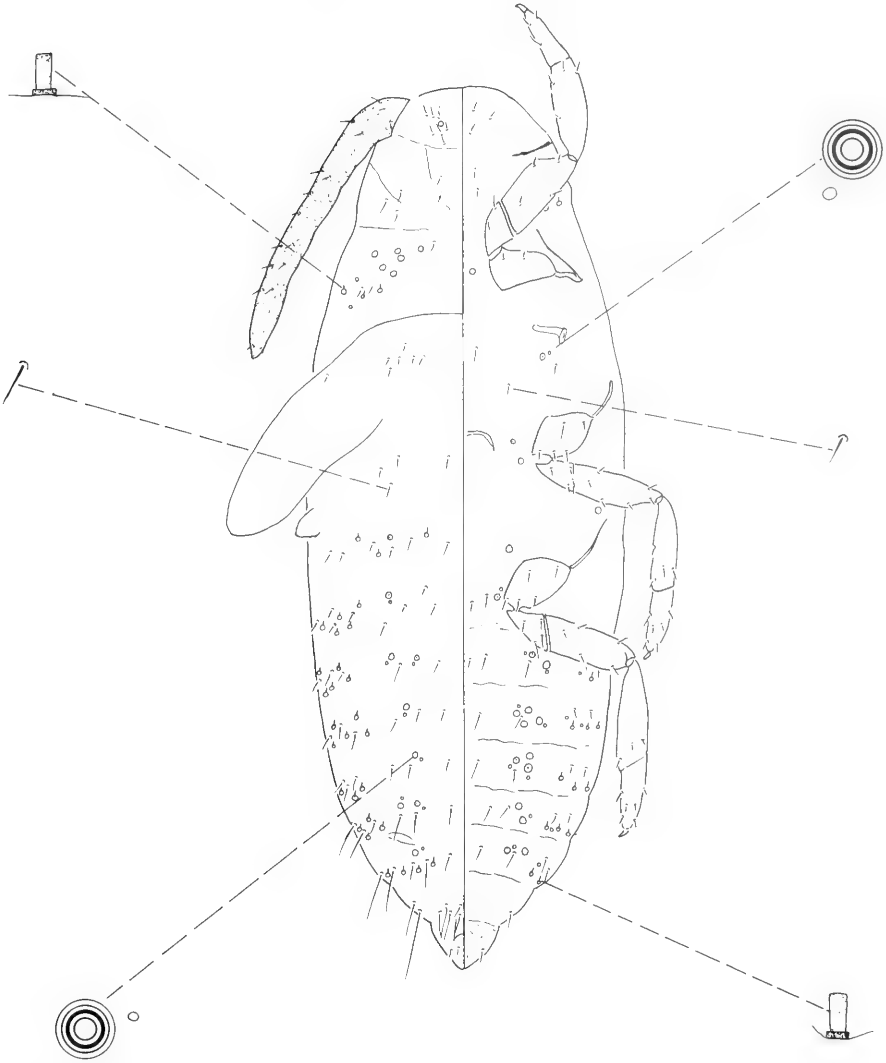

Fig. 7. Fourth-instar male (pupa) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

men, most abundant on prothorax; trilocular pores absent; discoidal pores associated with multilocular pores. Oral-collar tubular ducts of 1 size, present in submarginal areas of prothorax and abdomen. Longest submedial seta on segment VII 29(25–30) μ long; 5(4–5) submedial setae on segment VIII, longest seta 30(25–32) μ long.

Anal ring without setae and pores.

Venter with multilocular pores in mediolateral areas of thorax and abdomen. Trilocular pores absent. Discoidal pores associated with multiloculars. With oral-collar tubular ducts in marginal areas of prothorax and abdominal segments II or III to VII. Postocular ridge and mesosternal furca evident.

Antennae 10-segmented, 368(353–384) μ long. Legs without translucent pores. Femur 117(111–121) μ long; tibia 122(116–128) μ long; tarsus 96(94–99) μ long. Tibia/tarsus 1.3(1.2–1.3); femur/tibia 0.9(0.9–

1.0). Wing buds of mesothorax protruding from lateral margin, 289(248–347) μ long. Wing buds of hamulohalterae represented by small protrusions on lateral margin of metathorax.

Notes.—The above description is based on 3 specimens reared in the laboratory that originally were collected in Hammonton, New Jersey, March 19, 1996 and preserved June 6, 1996. We suspect that these specimens are pupae of the macropterous form. Specimens have also been collected near Frankfort, Sussex Co., Delaware, April 5, 1996 (1); Hammonton, New Jersey, August 8, 1996 (1), September 28, 1996 (4), October 30, 1996 (1). In most of these specimens, the apterous adult is inside. The pupa does not have wing buds except for a slightly wrinkled area where the mesothoracic wing bud would be on the macropterous form. The pupa can be distinguished from all other instars by having multilocular pores, oral-collar tubular ducts, 10-segmented antennae, no mouthparts, no aedeagus, definite constriction for the head. It is most similar to the prepupa. For a comparison see the notes section of the prepupa.

Macropterous Adult Male
(Fig. 8)

Slide-mounted characters.—Body elongate oval, 1.0 mm long, 0.3 mm wide.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate setae about 355μ long, 1 or 2 additional shorter setae, 32(30–34) multilocular pores, and 2 or 3 discoidal pores. Multilocular pores in marginal areas of thorax and abdomen, with 4 or 5 loculi, quadriloculars most abundant. Discoidal pores associated with multiloculars, with 1 or 2 near base of antenna, occasionally with 1 or 2 such pores in medial areas of abdomen. Body setae of 2 kinds, fleshy setae and bristle shaped; both kinds scattered over surface. Abdominal sclerotization restricted to abdominal tergite VIII. Metapostnotal ridge conspicuous. Scutellum rectangular, without scutellar ridge, with several setae laterally. Scutum sclerotized throughout except with a median longitudinal clear area, area lateral of prescutum heavily sclerotized, with reticulate pattern, scutum with many setae. Prescutum rectangular, with weakly defined prescutal suture, with several setae along lateral and posterior margins. Pronotal ridges heavily sclerotized. Hamulohalterae 65(64–67) μ long, with 1 apical hooked seta. Mesothoracic wings 796(790–883) μ long, each with 2 or 3 basal setae and 2 discoidal pores. Dorsal arm of midcranial ridge extending to posterior margin of dorsal eye. Dorsal medialsclerite sclerotized with numerous setae. Dorsal eye about 32μ in diameter. Lateral ocellus 21(20–22) μ in diameter, located at junction of preocular and postocular ridges. Ocular sclerite lightly sclerotized.

Penial sheath 147(146–148) μ long, 78(77–79) μ wide; length/width ratio 1.9. Aedeagus 116(111–121) μ long, apically truncate.

Venter with setae of same 2 shapes as on dorsum, present medially, submedially and laterally on most segments, abundant on basisternum. Abdominal sclerotization confined to sternite VIII. Prosternal ridge well developed, sternite weakly sclerotized. Preoral ridge weakly developed. Ocular sternite sclerotized near ventral eye. Ventral midcranial ridge well developed, with lateral arms. Ventral eye about 37μ in diameter.

Hind femur 171(168–174) μ long; tibia 211(210–212) μ long; hind tarsus 90(86–94) μ long; femur/tibia 0.8; tibia/tarsus 2.4(2.3–2.4). Slender fleshy setae present on legs and antennae; apical segment of antenna with capitate setae. Tarsal digitules capitate; claw digitules acute. Antennae 10-segmented, 536(521–546) μ long; segment 3 longest, 73(72–74) μ long; segment 10, 70(69–72) μ long; segment 3/10 1.0(1.0–1.1).

Notes.—The above description is based on 2 specimens reared in the Laboratory that originally were collected in Hammonton, New Jersey on *Vaccinium corymbos-*

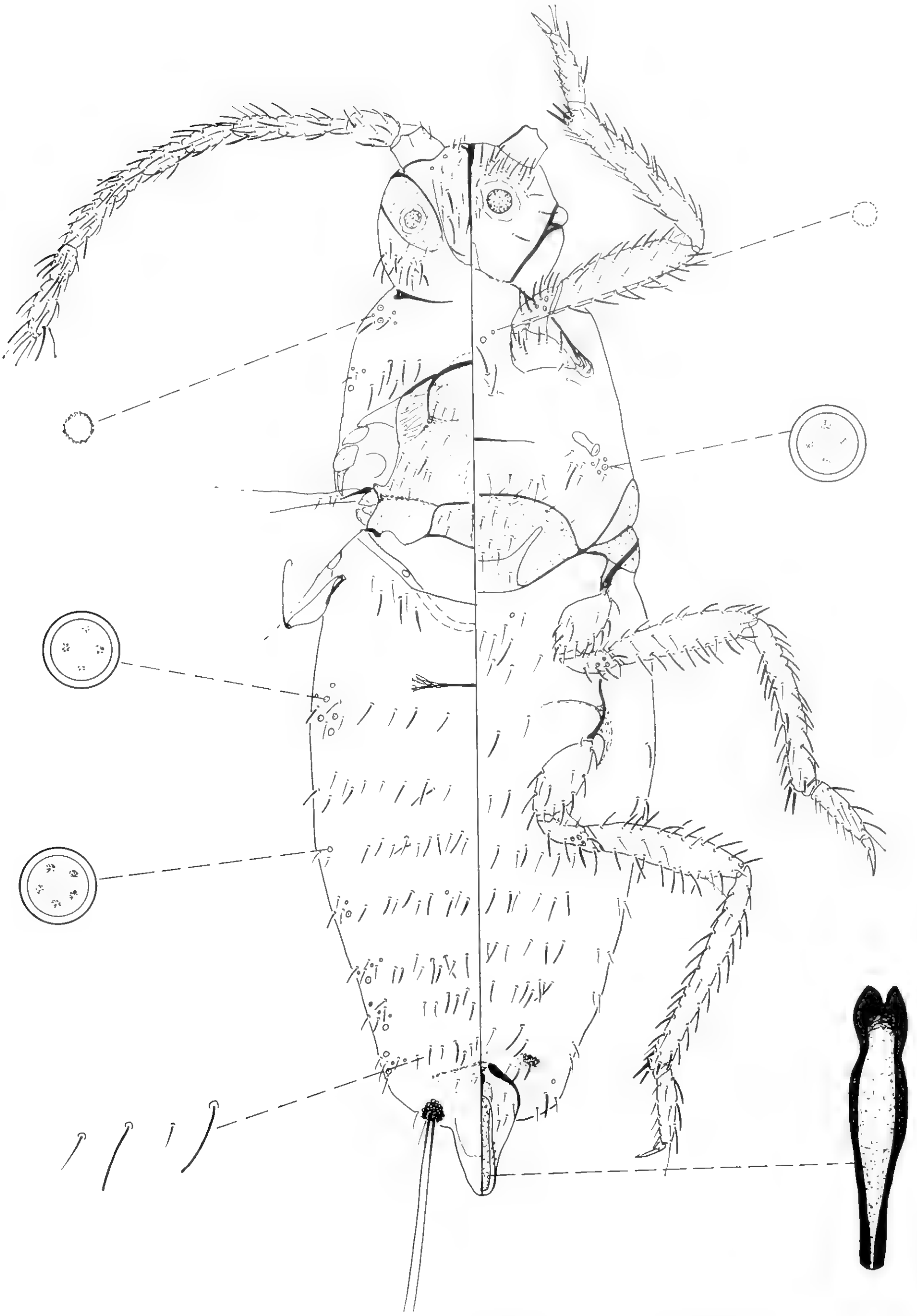

Fig. 8. Fifth-instar male (adult, macropterous form) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

um, March 19, 1996 and preserved June 6, 1996. Another specimen with brachypterous wings was reared at the same time. It is virtually identical with the macropterous forms but has small round wing buds and no hamulohalterae. It is unclear if this is a specimen that was in the process of wing elongation or is a naturally occurring brachypterous form. This macropterous form of the adult male can be distinguished from all other instars by possessing wings, a definite aedeagus, lateral pore clusters, and a heavily sclerotized thorax and head.

APTEROUS ADULT MALE
(Fig. 9)

Slide-mounted characters.—Body elongate oval, 1.2(1.0–1.2) mm long, 0.4 mm wide.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate setae 276(260–291) μ long, 1 or 2 additional shorter setae, 31(25–37) multilocular pores, and 2 or 3 discoidal pores. Multilocular pores in marginal areas of head, thorax and abdomen, with 3, 4, or 5 loculi, quadriloculars most abundant. Discoidal pores associated with multiloculars, with several near base of antenna, occasionally with 1 or 2 such pores in medial areas of abdomen. Body setae of 2 kinds, fleshy setae and bristle shaped; fleshy setae on abdomen, bristle-shaped setae scattered over surface. Abdominal sclerotization most conspicuous on abdominal tergite VIII and in lateral areas, weakly evident in mendial and submedial areas. Metapostnotal ridge inconspicuous. Scutellum, scutum, and prescutum fused into 1 sclerotized area. Hamulohalterae and mesothoracic wings absent. Dorsal arm of midcranial ridge variable, extending to posterior margin of dorsal eye in some specimens, represented by weak sclerotiztion on others. Dorsal medialsclerite unsclerotized with numerous setae, discoidals, and a few multilocular pores. Dorsal eye about 25(22–27) μ in diameter. Lateral ocellus 24(22–27) μ in diameter, located at junction of preocular and postocular ridges. Ocular sclerite lightly sclerotized.

Penial sheath 156(148–161) μ long, 87(79–91) μ wide; length/width ratio 1.8(1.7–2.0). Aedeagus 121(111–131) μ long, apically truncate.

Venter with setae of same 2 shapes as on dorsum, present medially, submedially and laterally on most segments, abundant on basisternum. Abdominal sclerotization confined to sternite VIII. Basisternum with anterior marginal ridge incomplete. Prosternal ridge well developed, sternite weakly sclerotized. Preoral ridge weakly developed. Ocular sternite sclerotized near ventral eye. Ventral midcranial ridge well developed, with lateral arms. Ventral eye about 33(30–35) μ in diameter.

Hind femur 181(172–191) μ long; tibia 210(200–221) μ long; hind tarsus 94(91–99) μ long; femur/tibia 0.8(0.8–0.9); tibia/tarsus 2.2(2.1–2.3). Slender fleshy setae present on legs and antennae; apical segment of antenna with capitate setae. Tarsal digitules capitate; claw digitules acute. Antennae 9- or 10-segmented, when 9-segmented, segments 4 and 5 fused, 486(477–502) μ long; segment 3 longest, 65(62–70) μ long; segment 10(9), 62(59–65) μ long; segment 3/10(9) 1.1(1.0–1.1).

Notes.—The above description is based on 5 specimens reared in the Laboratory that originally were collected in Hammonton, New Jersey on *Vaccinium corymbosum,* March 19, 1996 and preserved June 6, 1996. This form of the adult male can be distinguished from all other instars by having a definite aedeagus, lateral pore clusters, and a heavily sclerotized thorax and head, and by lacking wings.

SPECIMENS EXAMINED

Paratypes—DELAWARE: Near Frankford, Sussex County, IV-5-1996, on *Vaccinium* spp., S. Polavarapu and D. R. Miller (87 ad ♀, 48 third-instar ♀, 5 second-instar ♀, 1 fourth-instar pupal ♂, 28 second-instar ♂, 5 first instars) USNM. NEW JERSEY: Near Hammonton, Variety Farms, Atlantic

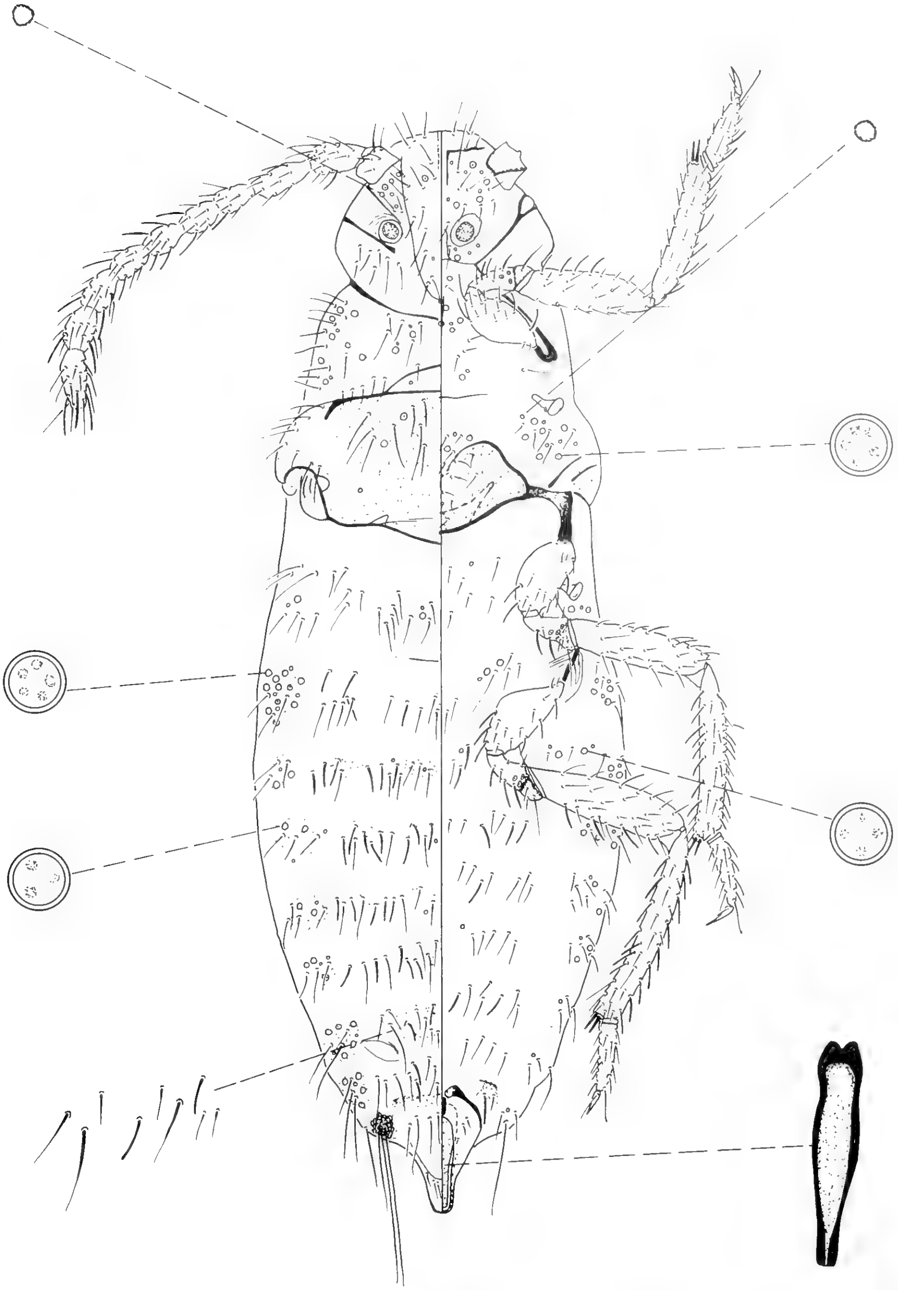

Fig. 9. Fifth-instar male (adult, apterous form) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller. Preserved after rearing in laboratory VI-6-1996.

County, V-12-1994, VI-7-1994, XI-17-1994, XII-30-1994, I-13-1995, III-14-1995, IV-14-1995, XI-1-1995, I-13-1995, II-12-1996, III-5-1996, III-19-1996, III-20-1996, IV-5-1996, IV-23-1996, V-6-1996, *Vaccinium* spp., (XI-1-1995 infestation also found on *Polygonum* sp.) D. R. Miller and/or S. Polavarapu (560 ad ♀, 235 third-instar ♀, 73 second-instar ♀, 2 macropterous ad ♂, 1 brachypterous ad ♂, 5 apterous ad ♂, 3 fourth-instar pupal ♂, 1 third-instar prepupal ♂, 75 second-instar ♂, 64 first instars) BMNH, CDA, FSCA, MHNH, UCD, USNM; Near Hammonton, MacCrie Brothers Farm, Atlantic County, III-5-1996, *Vaccinium* spp., S. Polavarapu and D. R. Miller (100 ad ♀, 30 third-instar ♀, 6 second-instar ♂, 1 first instar) USNM; Near Hammonton, MacCrie Brothers Farm, Atlantic County, VII-22-1993, IX-7-1993, IX-29-1993, *Vaccinium* spp., K. S. Samoil (24 ad ♀) USNM.

Not paratypes.—NORTH CAROLINA: Bailey, Nash County, I-25-1973, on *Vaccinium ashei,* H. H. Neunzig (6 ad ♂) USNM.

There is an additional series of specimens from the Hammonton locality that were collected August 8, 1996, September 28, 1996, and October 30, 1996. This material was mounted quickly for assessing the presence of different stages of the mealybug and therefore is not included in the type series. It includes 396 adult females, 139 third-instar females, 31 second-instar females, 111 first instars, 1 apterous adult male, 7 pupal fouth-instar males, 1 prepupal third-instar male, and 35 second-instar males. All of this material is deposited in the USNM.

Specimens collected in North Carolina are believed to be conspecific with *Dysmicoccus vaccinii* but have shorter appendages and shorter dorsal setae and therefore are not included in the type series. The submittal slip from H. H. Neunzig, North Carolina State reads "I am sending specimens collected from rabbit-eye blueberries (*Vaccinium ashei*) at a nursery in Bailey, N. C. They occur in large numbers and are forming galls on the roots. A white secretion is also associated with these insects." In New Jersey infestations we have never seen any indication of galls and have been unable to confirm their existence in North Carolina.

An additional series of specimens including 9 adult females, 3 third-instar females, and 4 first instars, was submitted to the Systematic Entomology Laboratory in 1984 by Donald Ramsdell of Michigan State University. Data on the slides indicate only that the specimens were collected on blueberry in New Jersey in November 1984. Since we do not have specific locality information, this series has not been included in the type series. The specimens fall well within the range of variation of *Dysmicoccus vaccinii.*

Field results.—Sampling of field populations during late fall of 1995 through fall of 1996 revealed the presence of various immature and adult stages throughout the sampling period (Fig. 10). Although second-instar males were consistently present, the adult males were found in the field only four times. One pupa was collected near Frankford, DE on April 5, 1996. In Hammonton, NJ male stages after the second instar were collected in the field on the following dates: one pupa (August 8, 1996); one prepupa, 4 pupae, and one apterous adult male (September 28, 1996); 2 pupae (October 30, 1996).

Adult females collected from the field during January and February readily oviposit in the laboratory. Eggs are laid within an ovisac made of wax filaments. *Dysmicoccus vaccinii* apparently has more than one generation each year in New Jersey.

In our field observations, we have always found *D. vaccinii* populations associated with the ants, *Acanthomyops claviger* (Roger) or *Lasius neoniger* Emery. These ant species were seen tending all stages of mealybugs. Ants were also seen carrying mealybugs especially in response to disturbance.

DISCUSSION AND CONCLUSIONS

Dysmicoccus vaccinii is part of a complex of mealybugs characterized by Beardsley (1965) as the *D. brevipes* group or the pineapple mealybug complex. Morphologically, they are recognized as species of *Dysmicoccus* that have most of the following characters: discoidal pores near the rim of the eye, multilocular pores restricted to the ventral surface of the abdomen, a cir-

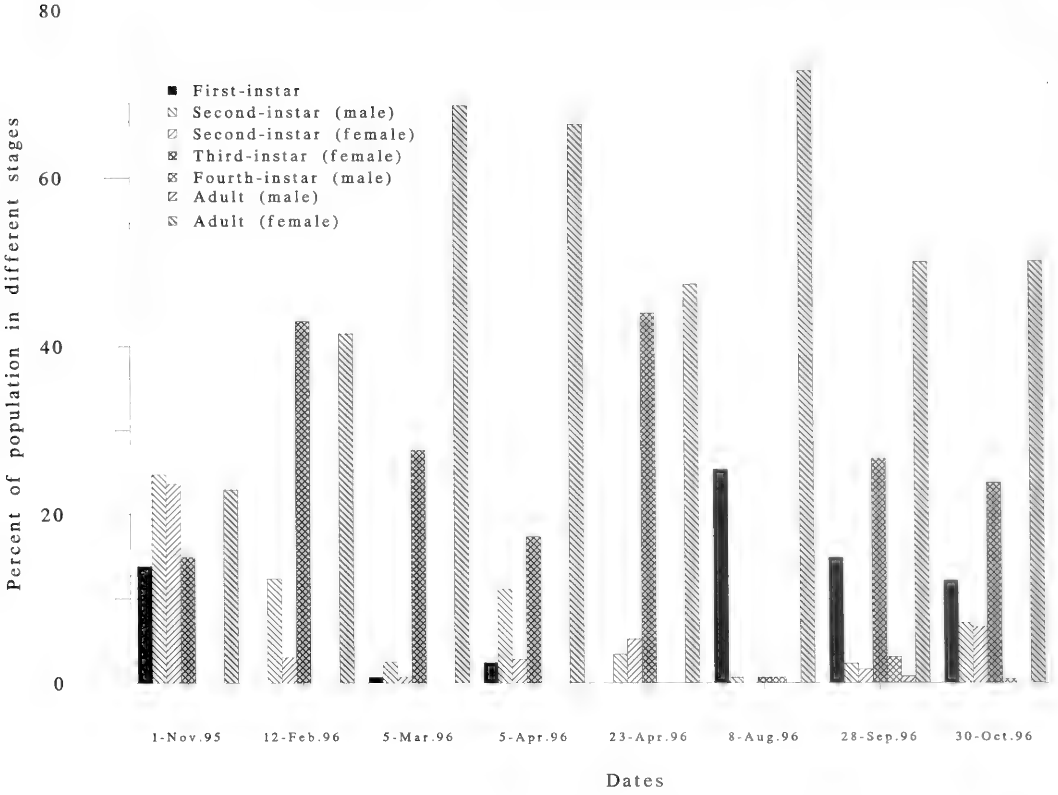

Fig. 10. Distribution of immature and adult stages of *D. vaccinii* on blueberries during November, 1995 to October, 1996, near Hammonton, New Jersey. Third-instar males are not included but one specimen was collected 9/28/96 and is 0.8% of total for that collection. Sample size was 65–439 mealybugs on different sampling dates.

culus divided by the intersegmental line, 17 pairs of cerarii, and translucent pores on at least the hind femur and tibia. With the addition of *Dysmicoccus vaccinii* to the group there now are 12 species in the complex including *D. brevipes, D. grassii* (Leonardi), *D. mackenziei* Beardsley, *D. morrisoni* (Hollinger), *D. neobrevipes* Beardsley, *D. pinicolus* McKenzie, *D. probrevipes* (Morrison), *D. radicis* (Green), *D. roseotinctus* (Cockerell and Cockerell), *D. texensis,* and *D. tibouchinae* (Hambleton).

The adult female of *Dysmicoccus vaccinii* is very similar to *D. texensis,* but differs by having no oral collars on the head, 1 size of oral collar on the body, the length of the hind femur divided by greatest width of the femur 3.1(2.9–3.4), and the longest dorsomedial seta on segment VIII 34(25–42) μ long. *Dysmicoccus texensis,* has several oral collars near the anterior margin of the head, 2 distinct sizes of oral collars, the length of hind femur divided by the greatest width of femur 2.0(1.9–2.1), and the longest dorsomedial seta on segment VIII 21(20–23) μ long.

The adult macropterous male is similar in appearance to the adult male of *Dysmicoccus grassii* (*=Dysimcoccus alazon* Williams) as described by Afifi (1968) but has an apically blunt aedeagus whereas *D. grassii* has an apically acute aedeagus. It also is similar to *Dysmicoccus brevipes* (Cockerell) and *D. neobrevipes* Beardsley as described by Beardsley (1965). *Dysmicoccus brevipes* and *D. neobrevipes* differ by having the apex of the aedeagus bifurcate; *D. neobrevipes* also has numerous short, enlarged setae on the antennae which do not occur in *D. vaccinii, D. grassii,* or *D. brevipes.*

The key to adult females of North American species of mealybugs presented by Miller and McKenzie (1973) needs to be modified as follows to accommodate *Dysmicoccus vaccinii.*

27(26). Oral-collar tubular ducts with dermal orifices noticeably larger in diameter than trilocular pores; lateral abdominal clusters of oral-collar tubular ducts each with fewer than 10 ducts . . . . *aurantius* (Cockerell)
– Oral-collar tubular ducts with dermal orifices smaller than or equal to diameter of trilocular pores; lateral abdominal clusters of oral-collar tubular ducts each with more than 10 ducts 28
28(27). Without oral-collar tubular ducts on head; with only 1 size of oral collar . . . . *vaccinii* Miller and Polavarapu
– With oral-collar tubular ducts on head; with 2 sizes of oral collars . . . . *texensis* (Tinsley)

One morphological result merits further discussion. As has been suggested previously (Miller 1975) the value derived from dividing the hind tibia length by the hind tarsus length is distinctive for each immature instar. In *D. vaccinii* these values are: adult female 2.0(1.8–2.3); third-instar female 1.2(1.1–1.2); second-instar female 0.9; second-instar male 1.0(0.9–1.0); first-instar 0.8(0.7–0.8). The interesting observation is that the value derived from dividing the hind femur length by the hind tibia length is basically the same for all instars. In *D. vaccinii* these values are: adult female 1.1(1.1–1.2); third-instar female 1.3(1.2–1.4); second-instar female 1.4(1.3–1.4); second-instar male 1.3(1.3–1.4); first-instar 1.4(1.3–1.5); only the adult female differs from the rest. Therefore, it appears that the tarsus is growing at a different rate than the other measurable segments of the leg.

In many insects, the diapausing stage is species-specific, and is reached prior to the arrival of adverse environmental conditions (Tauber et al. 1986). The occurrence of immature and adult stages of *D. vaccinii* throughout the fall and winter suggests the possibility that this insect does not have a true overwintering stage, although this does not preclude the possibility of overlapping diapausing and non-diapausing generations. For instance, the early-instar nymphs and mature adult females found during late fall and winter may represent diapausing and non-diapausing generations, respectively. Mature females collected during winter readily resume oviposition in the laboratory at 20–23°C. This suggests that mature mealybugs are in a state of quiescence awaiting the onset of favorable temperatures.

In the present study, the majority of the sampled population consisted of adult females at most times of the year. This may be partially attributed to the sampling bias against the immature stages of the mealybug population. Nevertheless, field samples collected throughout the study always consisted of immature stages including second-instar males. There may be a trend towards an increasing percentage of third-instar and adult females as winter progresses, but a more rigorous sampling regime is required to confirm this observation. Our failure to collect adult males on a regular basis, in spite of the common occurrence of second-instar males in the field, is difficult to explain. It is entirely possible that we simply are not locating the adults because of their small size and short life span. Clearly, more work is needed to understand the biology and seasonal life-history of *D. vaccinii.*

Ant-mealybug mutualistic relationships have been previously documented in the genus *Dysmicoccus* (e.g., Carter 1932; Milliron 1958; Beardsley et al. 1982; Rohrbach et al. 1988). Several species of ants feed on honeydew produced by the gray pineapple mealybug, *Dysmicoccus neobrevipes.* The ants are reported to benefit this mealybug species by providing protection from natural enemies and adverse weather conditions, by transporting the mealybugs among plants, and by removing honeydew which prevents sooty mold buildup (Rohrbach et al. 1988). Recent studies under laboratory conditions, however, failed to demonstrate the role of the big-headed ant, *Pheidole megacephala* (F.) in increasing the mealybug colony size or in transporting the mealybugs (Jahn and Beardsley 1996). Future research should evaluate the role of ants in maintaining populations of *D. vaccinii* in blueberry fields, to determine whether mealybug control strategies involving the management of ant populations should be developed and implemented.

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REDESCRIPTION OF *ANOPHELES* (*ANOPHELES*) *SHANNONI* DAVIS; A MEMBER OF THE ARRIBALZAGIA SERIES FROM THE AMAZON BASIN (DIPTERA: CULICIDAE)

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Abstract.—*Anopheles* (*Anopheles*) *shannoni* Davis is redescribed and illustrated in the adult female, male genitalia, and larval and pupal stages. This species is distributed throughout the Amazon Basin of South America. The larvae are found in shaded forest pools, and the adults appear to be zoophilic and prefer to bite outdoors. This species is a member of the Neotropical Arribalzagia Series.

Key Words: Diptera, Culicidae, Arribalzagia, *Anopheles shannoni,* redescription, Amazon Basin

Anopheles (*Anopheles*) *shannoni* Davis is a member of the Arribalzagia Series (Reid and Knight 1961). Wilkerson and Peyton (1990) implied that the approximately 23 species in this Neotropical group are monophyletic based on shared wing spot characters. Except for *An. vestitipennis* Dyar and Knab (Belkin et al. 1970), *An. malefactor* Dyar and Knab, *An. punctimacula* Dyar and Knab (Wilkerson 1990) and *An. calderoni* Wilkerson (Wilkerson 1991), these species are not adequately described. This redescription is part of an incremental effort to characterize the species in the group. In the following redescription Harbach and Knight (1980, 1982) were used for morphological terminology and numbering of larval and pupal setae and, Wilkerson and Peyton (1990) for wing spot nomenclature. Generic and subgeneric abbreviations follow Reinert (1975). An asterisk in a taxonomic citation indicates illustration of a given developmental stage. The specific feature(s) illustrated follows in brackets.

Anopheles (*Anopheles*) *shannoni* Davis

Davis 1931: 345 (female* [wing, hindleg]). State of Pará, Brazil. Holotype female (National Museum of Natural History, Washington, DC).

Female (Fig. 1).—Integument pale brown to dark brown, grayish brown pollinose. *Head:* Interocular space with 6–9 (*n* = 10 for this and following measurements and counts except where indicated) long, white setae and row of small, narrow, appressed pale yellow scales; vertex, occiput and upper portion of postgena with numerous erect, truncate scales; a patch of grayish white to pale yellow scales on dorsal area of vertex, nearly concolorous with scales on median area of anterior promontory, a patch of dark scales laterally on head concolorous with scales on lateral area of anterior promontory and upper antepronotum; head with 15–23 long, black ocular setae; postgena with long black setae ventrally. Clypeus bare. Pedicel of antenna with 4–10 small, dorsolateral, narrow to broad, grayish white

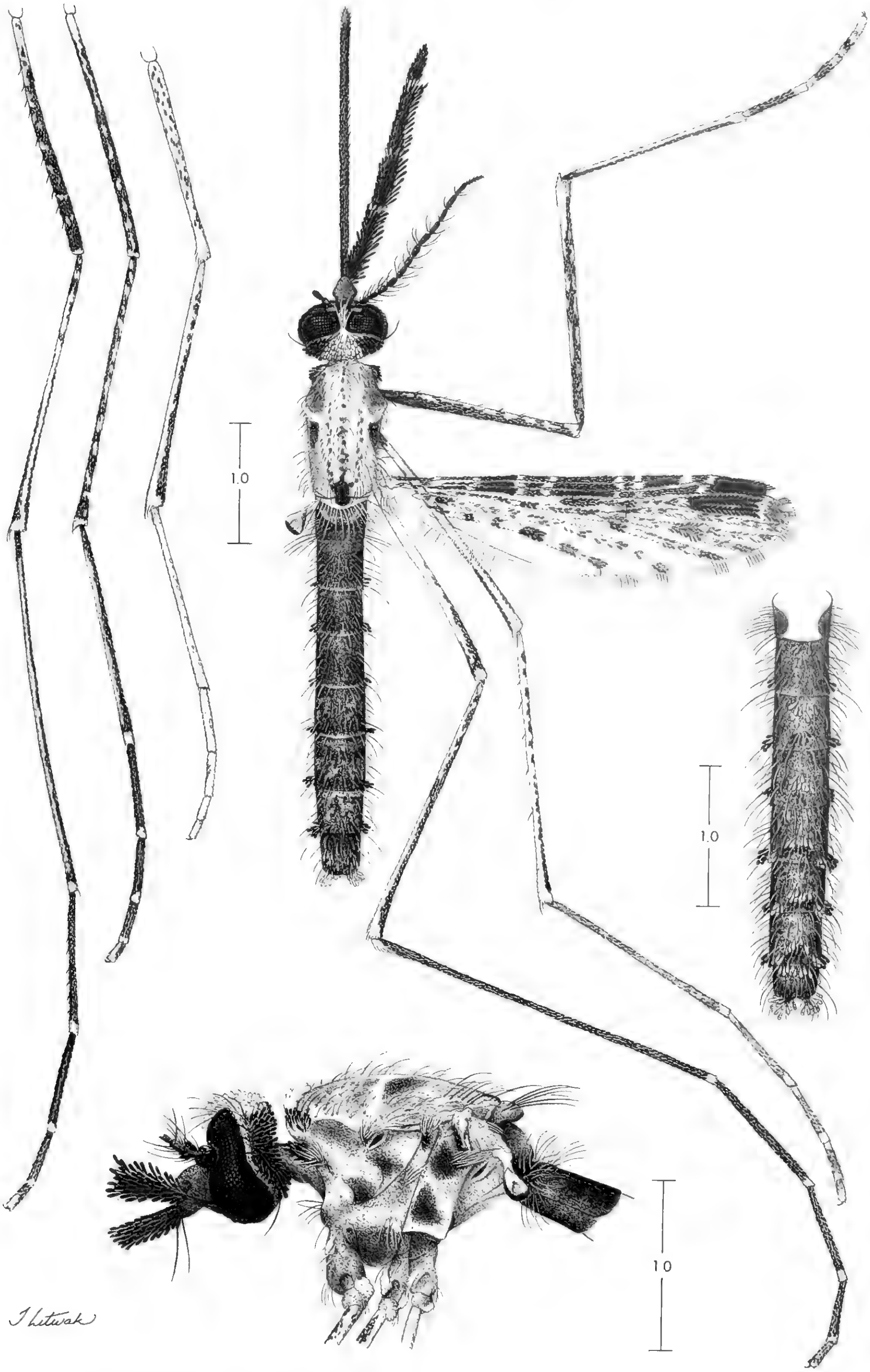

Fig. 1. *Anopheles shannoni.* Adult female habitus.

spatulate scales; flagellomere 1 with numerous narrow to broad, dark spatulate scales. Scales of maxillary palpus slender and spatulate, mostly dark brown with intermixed dark brown setae; scales on palpomeres 2–4 erect; pale yellow scales present on the bases of palpomeres 3, 4 and 5; length of maxillary palpus 1.99–2.61 mm (mean 2.27 mm); ratio of length of palpomeres 2–5 to total length of palpus, 2 = 0.26–0.35 (mean 0.31), 3 = 0.32–0.37 (mean 0.35), 4 = 0.17–0.22 (mean 0.20), 5 = 0.12–0.17 (mean 0.15); ratio of palpomere 4 to 5, 1.10–1.65 (mean 1.35); palpus 1.01–1.25 (mean 1.12) forefemur length. Proboscis with dark brown setae and decumbent dark brown scales, base with longer erect scales and setae; proboscis length 2.21–2.81 mm (mean 2.50 mm), proboscis 1.03–1.16 (mean 1.10) palpus length. *Thorax:* Integument brown to dark brown, silvery pollinose. Scutum with 3 prominent dark brown spots, 2 at the ends of and slightly posterior to prescutal sutures and another in prescutellar area continuing onto scutellum, sometimes 2 smaller spots at the ends of lateral portions of prescutellar area. Scutal setae numerous, pale yellow with golden reflections; scutum mottled with small dark brown spots mostly corresponding to setal insertions in acrostichal and dorsocentral areas; median anterior promontory with patch of long, narrow falcate white to pale yellow scales; scutal fossa without scales except anterior scutal fossa with patch of broad, spatulate dark brown erect scales, sometimes with a few intermixed pale scales; supraalar area with spatulate, elongate, narrow falcate, pale yellow scales. Scutellum with 11–23 shorter and 14–20 long, pale yellow setae. Antepronotum with 20–43 yellowish to dark brown setae and 10–20 upper, dark spatulate scales. Pleural vestiture as follows, with all scales white or pale yellowish white and spatulate: upper proepisternum with 3–6 setae, rarely with 1 narrow scale; prespiracular area with 6–13 setae, a single scale sometimes present; prealar area with 10–24 setae; upper mesokatepisternum with 3–6 setae, rarely with 1 narrow scale; lower mesokatepisternum with 2–5 setae, 7–9 scales; upper mesepimeron with 6–14 setae, 0–4 scales. Legs as figured, scales dark brown and white or pale yellow, scales and setae at apices of fore- and hindtibiae yellow. Distribution of scales on coxae and trochanters as figured. Extent and number of pale spots on femora and tibiae variable. Bases and apices of femora pale; mid- and hindfemora with ventral pale stripes, stripe on hindfemur distinct and with well demarcated borders; fore- and midtibiae with ventral longitudinal stripe of yellow scales, anterior, posterior and dorsal surfaces with yellow spots, hindtibia with an anterior longitudinal stripe of yellow scales and an indistinct stripe of pale yellow scales on posterior surface, basal portion with spots of yellow scales; foretarsomere 1 with a ventral stripe of pale scales, apex of foretarsomeres 1–5 with pale spots, more evident on anterior surface, 5 sometimes totally pale, midtarsomere 1 with indistinct pale stripe on ventral surface, apex of tarsomeres 1–5 with pale spots, these more evident anteriorly, anterior surface of hindtarsomere 1 with an indistinct longitudinal stripe of pale scales and with a few spots of pale scales at base, hindtarsomere 2 with intermixed pale scales, hindtarsomeres 1–5 with pale rings at apices. Forefemur length 1.76–2.28 mm (mean 2.03 mm), ratio of forefemur length to proboscis length 1.16–1.29 (mean 1.23). Wing (Table 1). Length (measured from humeral crossvein) 3.47–4.52 mm (mean 3.93 mm). Dark scales brown to black, pale scales nearly white. Basal pale spot usually present; prehumeral pale spot absent; subcosta basad of humeral crossvein with patch of dark scales ventrally, sometimes also with a few white scales; humeral crossvein dark-scaled dorsally and ventrally; accessory sector dark spot present; often 2 pre- and 2 postsubcostal pale spots and 1 pre- and 1 postsubcostal dark spot, less often a presubcostal and/or a postsubcostal pale spot and/or a postsubcostal dark spot ab-

Table 1. *Anopheles shannoni*: descriptive statistics for ratios of costal wing spot lengths to length of wing measured from the humeral crossvein (n = 10 wings from 10 individual females).

Wing Spot	Range	Mean	SD
Basal pale	0.00–0.01	0.01	0.00
Prehumeral dark	0.08–0.11	0.10	0.01
Humeral pale	0.01–0.02	0.02	0.00
Humeral dark	0.04–0.07	0.06	0.01
Presector pale	0.01–0.02	0.02	0.00
Presector dark	0.07–0.12	0.10	0.01
Sector pale	0.07–0.13	0.09	0.02
Accessory sector dark	0.13–0.37	0.24	0.02
Sector dark	0.13–0.17	0.15	0.02
Subcostal area	0.18–0.27	0.22	0.03
Presubcostal dark	0.00–0.06	0.03	0.02
Presubcostal pale (prox.)	0.01–0.04	0.02	0.01
Presubcostal pale (distal)	0.00–0.02	0.01	0.01
Postsubcostal dark	0.00–0.04	0.02	0.02
Postsubcostal pale (prox.)	0.04–0.05	0.02	0.02
Postsubcostal pale (distal)	0.00–0.03	0.01	0.01
Subcostal dark	0.08–0.12	0.10	0.01
Preapical dark	0.14–0.18	0.15	0.01
Preapical pale	0.01–0.05	0.03	0.01
Apical dark	0.00–0.10	0.02	0.04

sent; apical dark spot usually absent, occasionally represented by a few scales at the end of vein R_1 and sometimes dark scales on fringe. Spots on posterior veins variable; R_{4+5} sometimes mostly dark-scaled with intermixed pale scales, always with a small pale spot and distinct black spot at proximal end of vein, M_2 sometimes dark-scaled with intermixed pale scales, sometimes with a pale spot on proximal portion, sometimes with 2 black spots, one on proximal and another on distal end of vein, mcu at CuA variable from white-scaled to dark-scaled. Pale fringe spots indistinct, not well demarcated. Halter. Scabellum and ventral surface of pedicel with pale integument, dorsal surface of pedicel and capitellum with brown integument; pedicel and capitellum white-scaled dorsally, capitellum dark-scaled ventrally, concave center without scales. *Abdomen:* Integument brown to dark brown with some grayish pollinosity. Terga with numerous long yellowish setae; terga II–VII with erect, posterolateral, dark scale patches; tergum VIII with narrow, nearly white to yellow spatulate scales and also with patches of posterolateral, dark spatulate scales. Cercus distinctly constricted apically, pale yellow scaled. Sterna with scattered brown to yellow setae; sternum I without scales; sterna II–VII with scattered broad, white, spatulate scales and posteromesal patches of brown, dark, spatulate scales; sternum VIII with scattered, narrow, pale yellow and dark scales.

Male (Fig. 2).—As in female except for the following sexual differences. Maxillary palpus about 0.90 length of proboscis; apex of palpomere 3 and all palpomeres 4 and 5 enlarged, palpomere 4 about 4 times broader than base of palpomere 3. Maxillary palpus with dark brown and white to pale yellow scales; basal 0.5 of palpomere 2 with erect scales, apex with dorsolateral patch of white scales; palpomere 3 dark-scaled with an incomplete ring of white scales at base, a dorsolateral patch of white scales on basal 0.3 and a few scattered pale yellow scales; palpomere 4 mostly dark-scaled with scattered, pale yellow scales on dorsal and lateral surfaces and a patch of white scales at apex; palpomere 5 mostly dark-scaled with a dorsal patch of pale yellow scales at apex; palpomeres 4 and 5 mostly bare mesally, with long yellowish setae dorso- and ventromesally, 5 with scattered pale yellow scales. Proboscis length 2.87 mm, with small, decumbent, dark brown scales, and a ventrobasal patch of erect, dark scales, labella brown. Foreungues with curved submedian tooth and short, blunt, external basal tooth. *Genitalia:* Ninth tergal lobes short, somewhat triangular in outline, widely separated. Dorsal surface of gonocoxite with a few scattered, moderately long setae, lateral surface with slender fusiform and spatulate scales, ventral surface as dorsal surface but with lateral scales, most mesal parabasal spine stout with slender, recurved tip, borne on a slightly raised base; the other parabasal longer and more slender, both about 0.23 from base of gonocoxite; internal seta slender, about as long as most mesal parabasal, base about 0.75 distance from

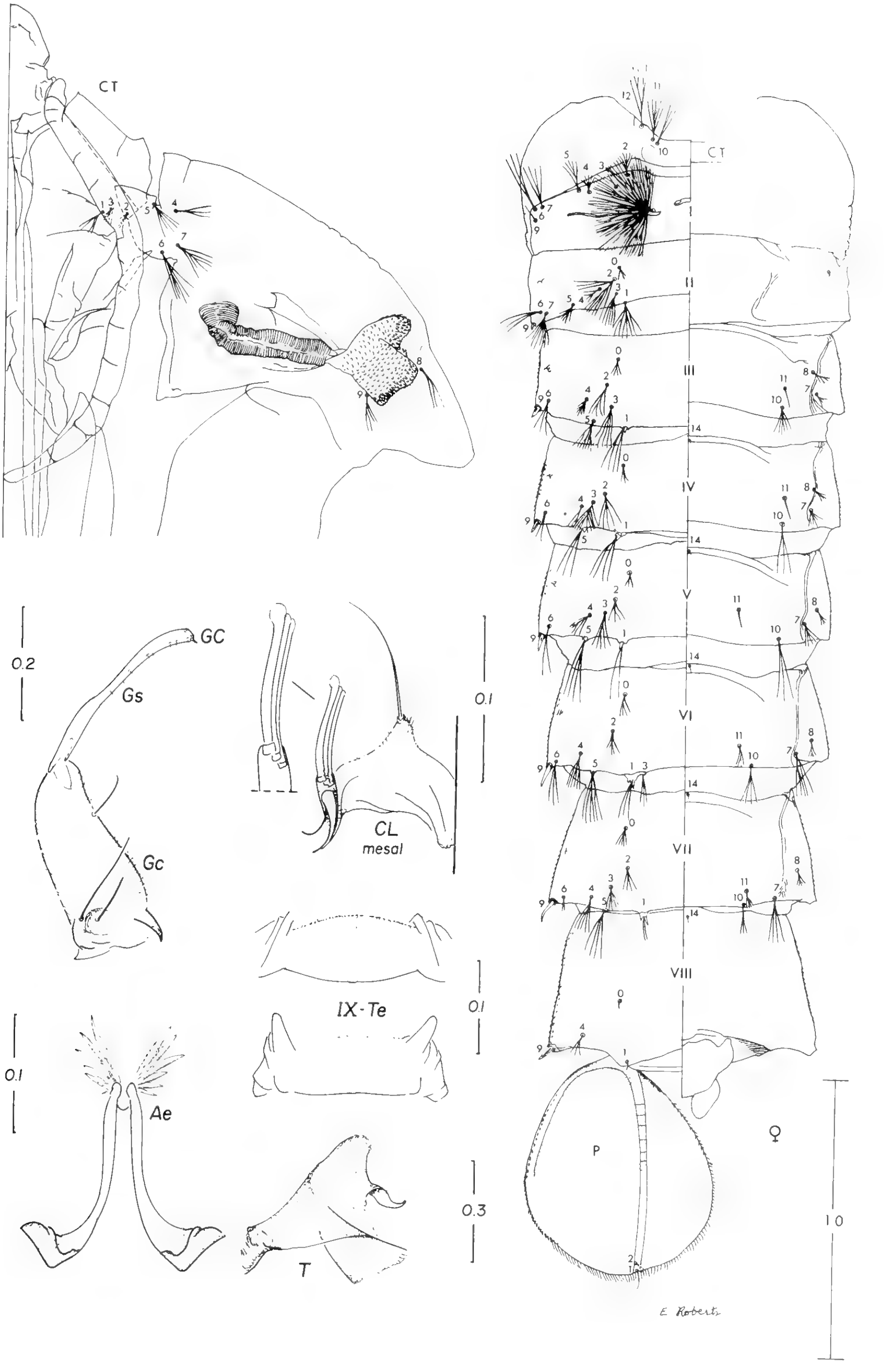

Fig. 2. *Anopheles shannoni.* Pupa and male genitalia. GC—gonostylar claw, Gs—gonostylus, Gc—goncoxite, Cl—claspette, IX-Te—tergum IX, Ae—aedeagus, T—trumpet.

Table 2. Pupal setal branching for *Anopheles shannoni*: range, mode ( ). Most are based on counts of twenty setae. In the case of equal modes, the highest is given. A range shown without a mode indicates that it was indefinite. Seta 8–II was found in only one specimen.

Seta No.	Cephalothorax CT	Abdominal Segments									Paddle P
		I	II	III	IV	V	VI	VII	VIII	IX	
0	—	—	1–4 (3)	1–7 (3)	1–6 (4)	1–5 (4)	2–6 (4)	2–6 (4)	1	—	—
1	2–4 (3)	13–23 (22)	5–10 (6)	3–7 (4)	2–5 (3)	1–3 (2)	1–3 (1)	1,2 (1)	1	1	1,2 (1)
2	2,3 (3)	2–10 (5)	6–8 (7)	5–8 (6)	3–5 (4)	3–5 (4)	4–6 (5)	3–6 (4)	—	—	1–3 (2)
3	2–4 (3)	1,2 (1)	2–5 (4)	3–7 (4)	4–10 (8)	3–7 (6)	2–6 (3)	3–8 (6)	—	—	—
4	2–5 (4)	2–8 (4)	2–6 (3)	3–6 (4)	2–6 (5)	4–8 (6)	3–6 (4)	3–6 (4)	3–5 (4)	—	—
5	3–6 (4)	3–5 (4)	4–7 (5)	4–9 (6)	2–5 (3)	2–5 (3)	2–5 (3)	2–4 (3)	—	—	—
6	3–7 (4)	2–4 (3)	2–5 (3)	2–6 (3)	1,2 (2)	2	1–4 (2)	1–4 (3)	—	—	—
7	4–8 (5)	3–6 (4)	3–8 (5)	2–6 (4)	2–7 (4)	2–6 (3)	2–5 (3)	2,3 (3)	—	—	—
8	2–6 (3)	—	2	1–5 (3)	1–5 (3)	1–4 (3)	2–5 (3)	3–6 (4)	—	—	—
9	2–5 (4)	1,2 (1)	1	2–6 (4)	1	1	1	1	1	—	—
10	2–5 (3)	—	—	1–4 (1)	1–4 (3)	2–4 (3)	2–4 (3)	2–5 (4)	—	—	—
11	4–7 (4)	—	—	—	1	1	2–5 (4)	2–5 (3)	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	1	1	1	1	1	1	—	—

base of gonocoxite. Claspette. Dorsal lobe of claspette with 3 strong, closely appressed setae, nearly equal in length, 2 setae inserted nearly at the same level, rounded in lateral view and 1 narrower seta inserted slightly basal to the other 2 setae; ventral lobe with 1 long, apical, slender seta; lateral and mesal surfaces of claspette with numerous small setae. Gonostylus with 10 minute setae on dorsal surface; gonostylar claw short, spiniform and blunt. Aedeagus with 5–8 pairs of leaflets, depending on position these appear as laminar, truncate at apex or bluntly pointed; the most mesal leaflet about 0.45 of aedeagus length, uniformly sclerotized, the other leaflets with the outer edge less sclerotized; largest leaflets with a few denticles toward apex and along one or both edges, no basal denticles apparent.

Pupa (Fig. 2).—Position and development of setae as figured; range and modal number of branches in Table 2. Integument weakly pigmented with a mottled pattern of dark pigmentation on wing case and leg cases, antennal case darker on outer 0.5 with dark pigmentation at flagellomere joints; integument near base of trumpet and metathoracic wings with poorly defined dark spots; paddle more darkly pigmented on anterolateral half. *Cephalothorax:* Trumpet laticorn, tragus finger-like, slender, tapered to apex. Secondary cleft absent. *Abdomen:* Terga and sterna II–VIII with numerous small spicules, more evident mesally and posteriorly; lateral margins of terga III–VIII with numerous spicules, most prominent on last segments. Setae 1-III–VII and 5-IV–VII surrounded by strongly sclerotized, spine-like protuberances, more prominent on segments V–VII. Seta 9-II–VIII peglike to long and pointed without aciculae. Segment VII 1.02–1.24 (mean 1.10) length of segment VI; segment VIII 1.13–1.55 (mean 1.41) length of segment VI. Width/length (width at posterior margins) of segment VI 2.58–2.94 (mean 2.75), VII 2.18–2.56 (mean 2.33), VIII 1.69–2.20 (mean 1.84). *Paddle:* Length 0.76–0.90 mm (mean 0.81 mm), width 0.62–0.74 mm (mean 0.68 mm), length/width 1.14–1.24 (mean 1.20); somewhat rounded, more strongly pigmented on basolateral half; refractile index 0.86–0.90 (mean 0.88); length of marginal spicules 0.03–0.05 mm (mean 0.04 mm).

Larva (Fig. 3).—Position and development of setae as figured; range and modal

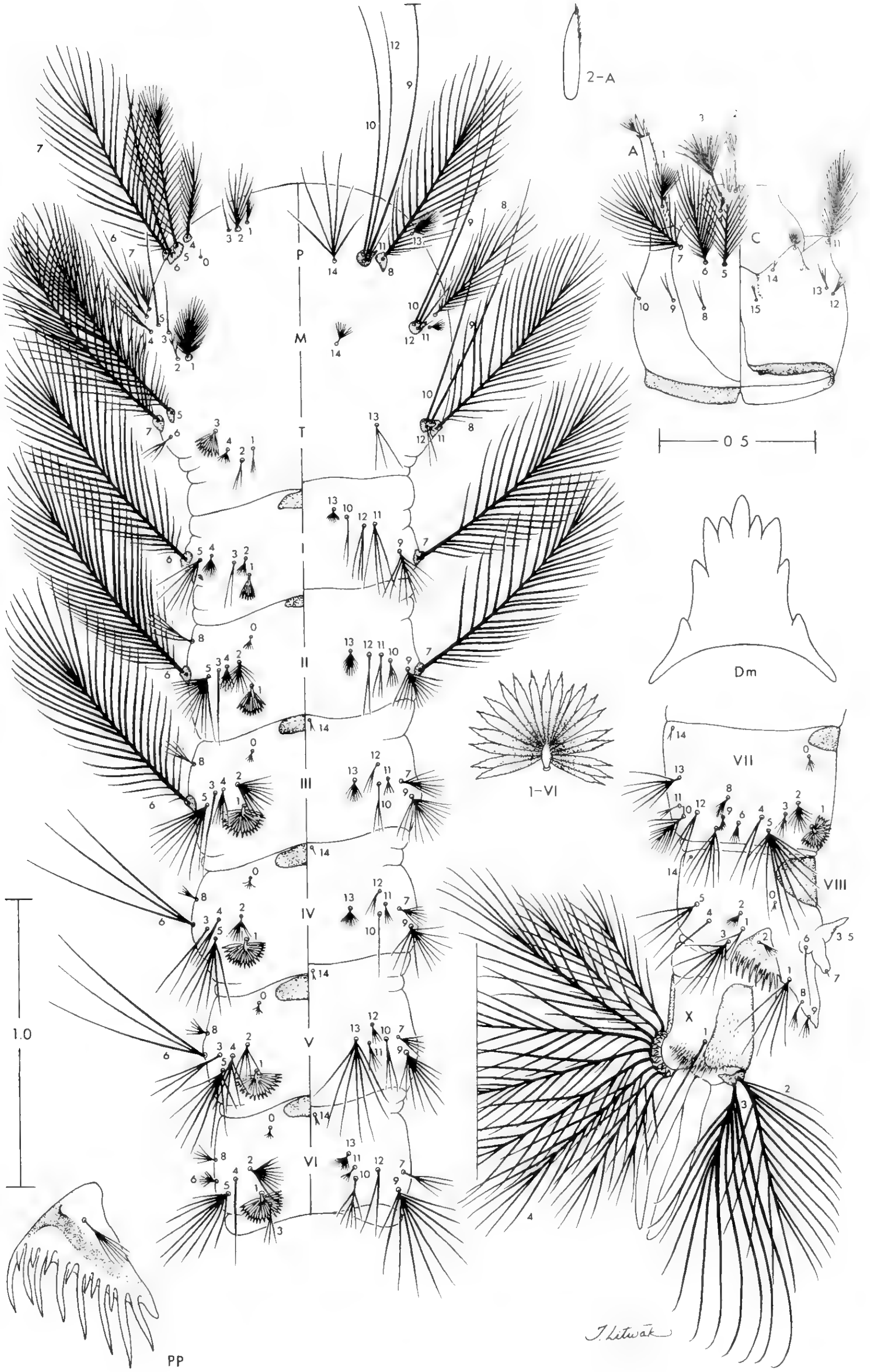

Fig. 3. *Anopheles shannoni.* Larva.

Table 3. Larval setal branching for *Anopheles shannoni*: range, mode (). Most based on counts of twenty setae. In the case of equal modes, the highest is given. A range shown without a mode indicates that the mode was indefinite.

Seta No.	Head	Thorax			Abdominal Segments				
	C	P	M	T	I	II	III	IV	V
0	—	1	—	—	—	3–5 (4)	3–8 (4)	4–6 (4)	3–5 (5)
1	1	2–5 (4)	21–30 (21)	2–5 (4)	3–9 (6)	6–14	15–20 (19)	18–22 (20)	14–20 (20)
2	1–9	7–12 (8)	2–6 (4)	2–5 (2)	4–9 (6)	8–12 (10)	6–11 (8)	2–8 (4)	2–5 (4)
3	14–24 (18)	1	1	7–14 (12)	1–4 (1)	1	1,2 (1)	2–4 (4)	2,3 (3)
4	4–7 (5)	9–17 (12)	2–4 (3)	4–7 (5)	7–11 (7)	6–8 (6)	3–5 (4)	3–5 (4)	3–5 (4)
5	17–26 (22)	>30	1	>30	4–7 (6)	7–14 (10)	7–11	4–6 (5)	4–8 (5)
6	16–24 (20)	1	2–5 (3)	3–5 (4)	>30	>30	>25	2,3 (2)	2,3 (2)
7	17–24 (19)	>30	3–7 (7)	>30	>30	>25	4–8 (5)	3–7 (4)	3–5 (5)
8	2,3 (2)	>30	9–19 (10)	>30	—	3–6 (4)	3,4 (4)	3,4 (4)	3–5 (5)
9	2	1	1	1	7–13 (7)	10–15 (15)	7–16 (10)	6–11 (7)	6–10 (10)
10	1–3 (2)	1	1	1	1,2 (2)	3–5 (4)	2,3 (3)	1–3 (2)	2–4 (3)
11	>20	1	1	1	3,4 (4)	2,3 (3)	2–4 (3)	3–5 (4)	2–4 (3)
12	2–4 (3)	1	1	2–4 (3)	2–4 (3)	2,3 (2)	2–4 (3)	3–5 (3)	2–5 (4)
13	2–4 (3)	13–26 (15)	5–10 (6)	3–5 (4)	5–11 (7)	7–16 (8)	6–13 (8)	5–13	5–7 (5)
14	1–4 (3)	5–9 (7)	5–19 (12)	—	—	—	1–4 (2)	1–3 (2)	1–3 (2)
15	1–7 (3)	—	—	—	—	—	—	—	—

number of branches in Table 3. *Head:* Antennal length 0.29–0.33 mm (mean 0.31 mm), tapered toward apex, 5.05–6.71 (mean 5.69) longer than wide; with spicules longer and more numerous ventrally and in vicinity of seta 1-A; dorsal surface with a few spicules; seta 1-A with 7–13 branches, inserted 0.26–0.32 (mean 0.30) from base of antenna; seta 2-A pointed. Seta 2-C varies from single and aciculate to strongly aciculate or with up to 9 branches on apical 0.3, length 0.90–1.16 (mean 1.04) length 3-C, seta 2-C close to mate of opposite side, distance between bases/width of base of single seta 1.06–1.98 (mean 1.64); 3-C 18 to 24 branched (mode 18), clypeal index (distance between bases of 2-C and 3-C on one side/distance between the bases of 2-C) 1.67-2.79 (mean 2.21). *Thorax:* Seta 1-P 2-5 branched; setae 9-12-P single; 12-M about 0.30 length of 9, 10-M; 11-M very short, single; 3-T weakly developed, palmate; 11, 12-T very short. *Abdomen:* Seta 1-I–VII palmate, seta 1-I,II weakly developed, leaflets broad, with jagged margins, apex weakly pigmented; 9-I with 7–13 branches; 8–II with 3–6 branches; 6-IV,V with 2,3 branches. Pecten with 15–20 teeth; arrangement of teeth alternating long and short, with 7–10 long and 7–11 short; long spines 2.26–3.93 (mean 3.17) length of short spines. Seta 1-X not inserted on saddle. Integument of posterior margin of segment X with numerous, strongly developed spicules.

Material examined.—Holotype ♀ with the following labels: handwritten "shannoni"; a printed red label "type no. 44166 USNM"; two printed white labels, one "Para, Braz. Apr. 1930, N.C. Davis", another "animal bait". Paratypes, 2 ♀; same as holotype (one marked by RW as probably a paratype did not have an original paratype label). In addition, 49 ♀, 4 ♂, 13 larval exuviae, 15 pupal exuviae and 4 ♂ genitalia as follow. BRAZIL, Pará State, Belém City, Nova Timbo, 3 progeny broods from females collected from human bait, 10.V. 1989 by J. B. Lima: BR 002(1), 1 ♀ 2 Le 2 Pe; BR 002(2), 2 ♀ 2 ♂ 4 Le 4 Pe; BR 002(3), 7 ♀ 1 ♂ 1 ♂ gen. 8 Le 9 Pe; BR 002(×), 2 ♀; biting cow, 14.IV.194?, Komp coll. and det., 1 ♀; Amazonas State, Lábrea, Rio Ituxí, Floresta, 18.1.1984, J. Bento coll. and det., 1 ♂ 1 ♂ genitalia; Manaus, VI.1931, R.C. Shannon col. and det.,

Table 3. Extended.

Abdominal Segments			
VI	VII	VIII	X
2–5 (4)	1–5 (4)	1–4 (2)	—
15–22 (19)	13–22 (17)	2,3 (2)	1
6–10 (7)	7–12 (8)	5–8 (6)	18–25 (20)
1–4 (2)	3–7 (5)	6–10	4–6 (6)
1	1–3 (2)	1	9,10 (9)
6–9 (8)	7–11 (9)	4,5 (5)	—
4–8	4–8 (6)	1-S	4–7 (6)
3–7 (3)	4–7 (4)	2-S	4–8 (4)
4,5 (5)	6–8 (7)	6-S	1,2 (1)
6–10 (10)	4–8 (5)	7-S	1
4–6 (5)	7–15 (11)	8-S	1–4 (3)
3–5 (3)	3	9-S	2–5 (4)
1–3 (2)	2–4 (3)	—	—
6–11 (9)	4–7 (5)	—	—
2,3 (2)	1–3 (1)	1	—
—	—	—	—

3 ♀. PERU, Iquitos, III,IV.1931, R.C. Shannon coll., 15 ♀. GUYANA, Sector Malar. Lab. TS&B.C., 19.VII.1944, T.K. Yolles coll. and det. 1 ♀; on man, 1942, T.K. Yolles coll. and det., 16 ♀. SURINAM, Paramaribo, biting man, 3.IX.1943, D.G. Hall coll., 1 ♀.

Annotated bibliography.—Shannon 1933: 136 (♂; ♀* [genitalia, marginal wing scales, halter]; pupa* [trumpet, cephalothorax, abdomen]. Iquitos, Peru; Belém and Manaus, Brazil); Vargas 1942: 72 (♀, key); Russell et al. 1943: 49 (♀, key. British Guiana); Cerqueira 1943: 18 (Beni and Terr. de Colonias, Bolivia); Causey et al. 1944: 3 (egg*, key); Causey et al. 1946: 26 (♂* [claspette, aedeagus], key); Deane et al. 1946a: 13, (♀* [wing, cerci, hindtarsomere 1], key); Deane et al. 1946b: 37, 41 (larva* [setae 2,3,4-C, antenna, setae 1,2,3-P], key. Mato Grosso, Amazonas and Pará, Brazil); Deane et al. 1948: 917 (distribution map, northern Brazil); Correa 1950: 81 (♀ and larva in keys); van der Kuyp 1950: 63 (♀, ♂ and larva, in keys. Moenga, Surinam); Lane 1953: 204 (♀* [wing], key; ♂; pupa* [trumpet, abdomen]; larva* [illus. from Deane et al. 1946b]; egg* [illus. from Causey et al. 1944]); Vargas 1959: 385 (♂ gen. in key); Forattini 1961: 172, 181, 186 (♀, ♂ gen. and larva in keys); Forattini 1962: 342 (♂ gen.* [claspette, aedeagus], key; ♀ and larva in keys); García and Ronderos 1962: 149 (♀* [wing], key; ♂ gen. in key; larva* [setae 2,3-C, 6-IV,V], key); Gorham et al. 1967: 25, 40, 61; (♀ and larva in keys); Morales-Ayala 1971: 138 (Loreto, Peru); Rambajan 1987: 149 (Guyana).

Distribution.—Reported from northern Amazonian Brazil, Guyana, eastern Peru, Bolivia and Surinam. From this distribution it can be assumed to also occur in Amazonian Ecuador, Colombia and Venezuela.

Biology.—Little is known about the biology of adult and immature stages of *An. shannoni.* The type specimens were captured with animal bait inside the jungle during morning and evening hours. Adults were observed to be zoophilic since they were rarely found in houses, but commonly collected in animal shelters. Adults were also collected with a Shannon trap in the Amazon forest. Larvae were reported from forest ponds or pools (Deane et al. 1946b, Shannon 1933), from stagnant river waters and small shaded streams, and in flooded forests with clear water generally full of decomposing leaves, among shrubs and tree trunks (Deane et al. 1948). Deane et al. (1948) also reported that the larvae were found associated with *An.* (*Nyssorhynchus*) *darlingi* Root and *An.* (*Ano.*) *mediopunctatus* (Theobald) and that adults seldom entered houses and fed mostly on horses at dusk.

Discussion.—In comparison to other species in the Arribalzagia Series (subgenus *Anopheles*) (Reid and Knight 1961, Wilkerson and Peyton 1990), the adult female *An. shannoni* is similar to *An. minor* Da Costa Lima, *An. peryassui* Dyar and Knab and *An. mattogrossensis* Lutz and Neiva in having mostly dark-scaled tarsi with narrow rings of pale scales at the tarsomere articulations. However, the former two species have posterolateral abdominal scale tufts and speckled tibiae and femora, while *An.*

peryassui and *An. mattogrossensis* have neither. In many other respects *An. shannoni* is quite similar to *An. minor* but *An. shannoni* has wide wing scales, the apical half of the cercus is strongly constricted and there is no speckling on hindtarsomere 1. *Anopheles minor* has narrow wing scales, a rounded cercus and speckling on hindtarsomere 1.

The male genitalia of *An. shannoni* has the ninth tergal lobes short and triangular while they are short to long but rounded in the other three species. *Anopheles shannoni* has 5–8 large subequal aedeagal leaflets with one edge usually thinner and nearly transparent, and with small apical denticles. *Anopheles minor* and *An. mattogrossensis* both have one pair of leaflets (*An. minor* also has several very small pairs) and *An. peryassui* has 4–5 pairs of uniformly sclerotized leaflets without denticles. Of the four species only *An. shannoni* has a single primary seta on the ventral lobe of the claspette.

In the larval stage *An. shannoni* can be distinguished from other *An.* (*Anopheles*) by the following combination of characters: seta 2-A lanceolate with a fine apical fringe on one margin; seta 3-C with 18–24 branches; seta 1-P short with 2–5 branches; setae 9-12-P single; seta 6-IV,V 2–3 branched and; the pecten plate with alternating short and long teeth.

In the pupal stage, *An. shannoni* can be easily recognized by setae 1-III–VII and 5-IV–VII which have bases surrounded by spinelike projections. Also, the trumpet has a slender, fingerlike tragus, the secondary cleft is absent and the paddle is strongly pigmented on the basolateral half.

The egg is unusual in having numerous frills (Causey et al. 1944, Lounibos et al. in press), similar to *An. peryassui* Dyar and Knab (Causey et al. 1944, Linley and Lounibos 1994).

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A NEW GENUS AND SPECIES OF ALLANTINAE (HYMENOPTERA: TENTHREDINIDAE) FROM SOUTHEASTERN UNITED STATES

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Abstract.—***Allantunicus autumnalis,*** a new genus and a new species of Tenthredinidae, subfamily Allantinae, is described from the sand dune area of coastal Alabama. The genus and species are diagnosed and compared to other North American Allantinae. Evidence strongly suggests that the larva feeds on inflorescences of *Polygonella gracilis* (Polygonaceae).

Key Words: sawfly, Tenthredinidae, Allantinae, *Polygonella gracilis,* Polygonaceae

The specimens on which the following new genus and new species are based were collected in autumn from *Polygonella gracilis* (Nutt.) Meisn. (Polygonaceae) in the sand dune area of coastal Alabama. Observations from separate larval collections in this same area strongly suggest that the larva feeds on the inflorescences of *Polygonella gracilis,* a plant of the sandhills of the Coastal Plain of the southeastern United States. A single specimen was initially discovered in the collection of the Mississippi Entomological Museum. In October 1996, the junior author visited the same collecting area and obtained additional specimens, including males. The new genus and species is morphologically distinct from all other North American Allantinae, and its presumed habits are unique among the Allantinae. Some of the remaining sawflies to be discovered in the Nearctic Region no doubt live in restricted habitats and are active during an unusual time of the season. The possibility of this being an adventive species was explored; however, there are no Neotropical allantines similar to this species and no genus and species comparable to it from the rest of the world.

Allantunicus Smith, new genus

Type species.—*Allantunicus autumnalis* Smith, new species.

Antenna (Fig. 4) filiform; 1st and 2nd segments each longer than broad; 3rd segment about 1.7 × longer than 4th segment. Head narrowing behind eyes in dorsal view, distance behind eyes equal to half visible eye length; postocellar area as broad as long; mandibles symmetrical, each bidentate; malar space nearly linear; clypeus shallowly emarginate, laterally acute without rounded lobes; short genal carina indicated only below eye near mandible. Propleura broadly rounded and meeting on meson; mesopleuron and mesonotum smooth, without punctures. Tarsal claw (Fig. 3) with small inner tooth at center of claw, shorter than outer tooth; basal lobe absent. Abdomen without pairs of white spots on dorsum. Forewing with anal crossvein oblique, with 4 cubital cells, M and Rs + M meeting Sc + R at same point. Hindwing without cells Rs and M; length of petiole of anal cell about half width of cell.

Etymology.—The name is based in part on the subfamily name, Allantinae, and the Latin *unicus,* indicating the unusual and unique characteristics of the genus.

Discussion.—The genus is separated from other allantine genera by the following combination of characters: short genal carina present only near mandible below eye; shallow clypeal emargination with acute lateral lobes; smooth, shining thorax without punctures on mesepisternum; short inner tooth of the tarsal claw; lack of closed cells Rs and M in the hindwing; and third antennal segment longer than fourth segment. *Allantunicus* will key to *Somanica* Smith in couplet 12 of my key to genera (Smith 1979). *Somanica* differs from *Allantunicus* by the subequal third and fourth antennal segments, lack of a genal carina, rounded lateral lobes of the clypeus, and long inner tooth of the tarsal claw, nearly as long as the outer tooth. In addition characteristics of the sheath and lancet (Figs. 1, 2, 5) of *Allantunicus* are unique among Nearctic Allantinae, namely the emarginate apex of the sheath in lateral view, slight widening of the sheath toward the apex in dorsal view, and presence of ctenidia on the annuli of the lancet.

Allantunicus belongs to the tribe Empriini, as defined by Smith (1979): mandibles symmetrical, bidentate; clypeus shallowly emarginate, propleura meeting broadly on the meson; mesopleuron without punctures; and veins M and Rs+M meeting Sc+R at the same point in the forewing.

This does not appear to be an adventive taxon. A survey of material in the National Museum of Natural History, Smithsonian Institution, and use of Malaise's (1963) key to world genera indicated no similarities to exotic taxa. *Allantunicus* runs to couplet 106 in Malaise's key which identifies *Mallachiella* Malaise (from Burma and the Himalayas) and *Heptapotamius* Malaise (from Turkestan). *Mallachiella* differs by the presence of a basal lobe on the tarsal claw, a compressed antennal flagellum, subsymmetric mandibles, and a very deeply, semicircularly incised clypeus with long, acute lateral lobes. *Heptapotamius* differs by the head strongly enlarged behind the eyes in dorsal view, and the clypeus incised for about a quarter of its medial length and with blunt lateral teeth.

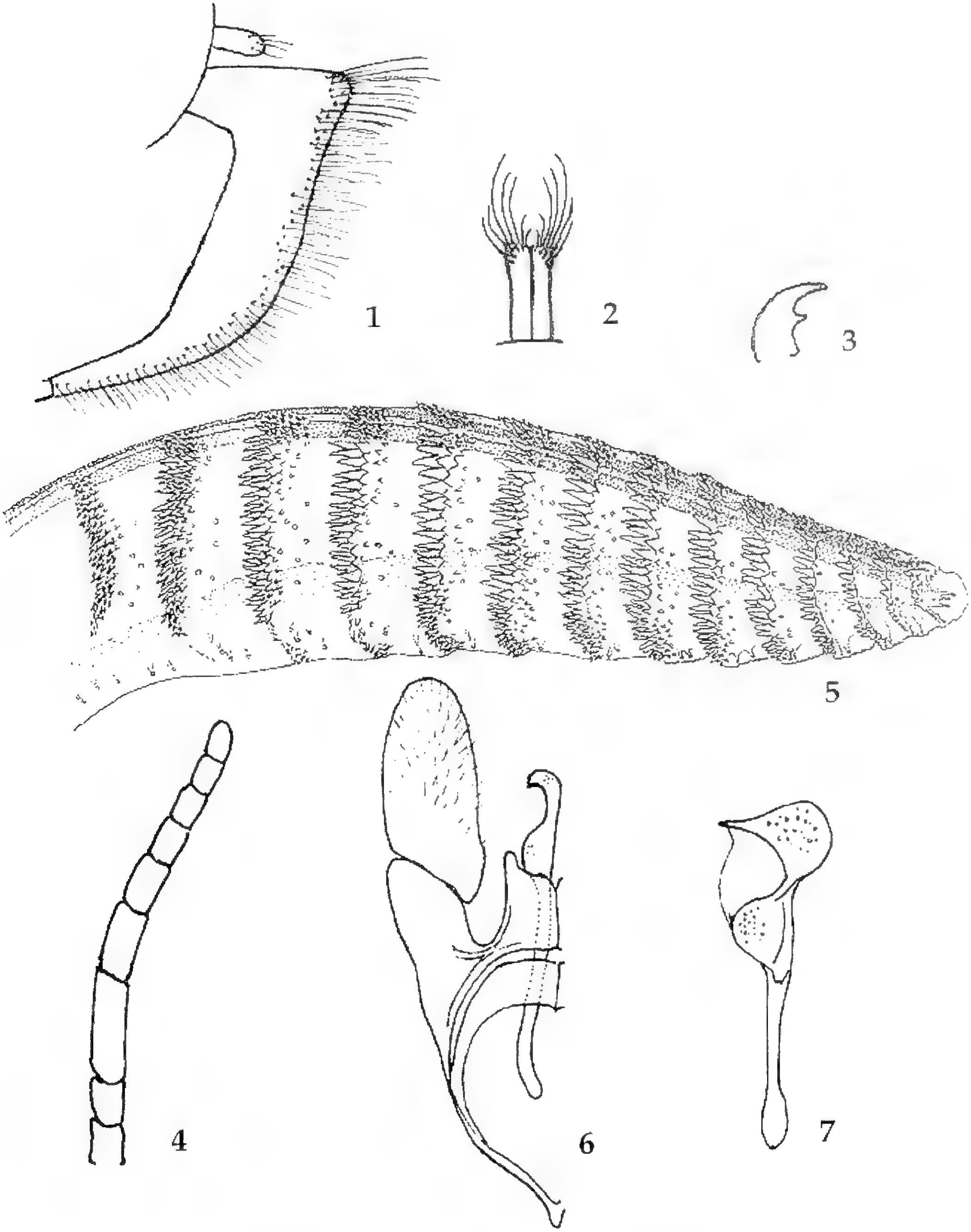
***Allantunicus autumnalis* Smith, new species**
(Figs. 1–7)

Female.—Length, 8.5–9.0 mm. Antenna and head black; mandible dark orange with apex blackish, clypeus whitish; basal 3 maxillary palpal segments and labial submentum orange, rest of palpi and labium blackish. Thorax orange with anterior margin of propleuron, entire prosternum and mesosternum, and spot on lower portion of metepimeron, black. Abdomen orange; sheath black. Legs orange with apical 3 midtarsal segments and entire hindtarsus blackish. Wings moderately, uniformly infuscated; veins and stigma black.

Antenna as in Fig. 4, length 1.6× head width. Eyes slightly converging below; lower interocular distance subequal to eye length. Hindbasitarsus shorter than remaining hindtarsal segments combined, ratio 1.8:3.0. Head and body entirely shining and impunctate. Sheath (Figs. 1, 2) in lateral view with posterior margin slightly concave, in dorsal view slightly expanded toward apex with indication of small scopa; with long hairs curved mesally. Lancet as in Fig. 5, with stout ctenidia on annuli; serrulae low, only apical 7 with fine posterior subbasal teeth.

Male.—Length, 8.0–9.0 mm. Coloration similar to female. Genitalia as in Figs. 6, 7.

Holotype.—Female from Alabama, labeled "Ala., Baldwin Co., Gulf Shores, 30°16′47″ N, 87°42′49″ W, 16 Oct. 1996, T.L. Schiefer," "on flowers of Polygonella gracilis in dredge spoil dunes," Deposited in the National Museum of Natural History, Smithsonian Institution, Washington D.C. on indefinite loan from the Mississippi En-



Figs. 1–7. *Allantunicus autumnalis.* 1, Sheath, lateral view. 2, Sheath, dorsal view. 3, Tarsal claw. 4, Antenna. 5, Lancet. 7, Male genitalia, genital capsule, left side, ventral view. 7, Male genitalia, penis valve, lateral view.

tomological Museum, Mississippi State University.

Paratypes.—ALABAMA: Same data as holotype (4 ♀); same data but 17 Oct. 1996 (3 ♀); same data but 14 Oct. 1991 (1 ♀); same data but 17 Oct. 1996, in flight near *Polygonella gracilis* in dredge spoil dunes (5 ♂); same data but 17 Oct. 1996, 30°16′52″ N, 87°42′03″ W, on flowers of *Polygonella gracilis* in dredge spoil dunes (2 ♀, 1 ♂). Deposited in the Mississippi Entomological Museum, Mississippi State University; National Museum of Natural History, Smithsonian Institution, Washington, D.C.; and Canadian National Collection, Ottawa.

Etymology.—The name is derived from the autumn flight of the species.

Host.—*Polygonella gracilis* (Nutt.) Meisn., wireweed (Polygonaceae) (see discussion).

Color variation.—Several specimens differ in color from the typical form as described. The mesosternum and mesepisternum of two females are mostly black except for the orange upper third of the mesepisternum and most of the metepisternum, cervical sclerites, metapleuron, and base of midcoxa. One male has a black mesosternum and mesepisternum except for a small orange spot on the upper corner of the mesepisternum, the metepleuron, and most of the lateral lobes of the mesonotum.

Discussion.—On 16–17 October 1996, the junior author collected most of the type series from *Polygonella gracilis* in a sand dune area at Gulf Shores, Alabama. All were net-collected on flowers or in flight near the plants. The 11 specimens collected on flowers were always oriented in alignment with the axis of the flower cluster. They were found on both horizontal and vertical flower clusters with their head facing either toward or away from the main stem of the plant. All except two of these individuals were sitting motionless on the flowers. One female observed in late afternoon occasionally turned around on the flower cluster to face the opposite direction. It appeared to be tapping the flowers with its antennae, but no oviposition was observed. The next morning another individual was observed flying from one flower cluster to another on the same plant and then turning around several times like the one observed the previous afternoon. Two individuals were on flower clusters in which most of the flowers had not yet opened. The five specimens collected in flight that morning flew among the *Polygonella* in a fairly slow and erratic zigzag pattern. However, their evasive flight was very fast and direct. After about 10:30 am, there appeared to be a marked decrease in sawfly activity, and no additional specimens were observed at the type locality. This corresponded to an increase in temperature and increased pollinator activity. However, three additional specimens were collected about noon in similar habitat 0.6 miles from the original site. Only males were caught in flight; all females and one male were taken on the flower clusters.

Polygonella gracilis grows in the pure white sand characteristic of the dune habitats in the vicinity of Gulf Shores. The foredune and backdune habitats close to the coast would seem to be suitable habitats for the sawfly since *P. gracilis* is present. But despite several Malaise traps set for two days in these habitats and much visual searching, no sawflies were found there. The sandy areas where the sawflies were collected are along the north side of the Intracoastal Waterway where *P. gracilis* is more abundant. This habitat is apparently man-made having been created through the dumping of spoil from the dredging of the waterway. The area has subsequently been colonized by vegetation more characteristic of the foredune and backdune habitats that lie several miles closer to the coast. According to Paul Warren, Army Corps of Engineers, Mobile District, Irvington Office (personal communication), the first channel for this section of the waterway was dug in 1934 and then enlarged in 1944. This probably accounts for much of the dredge spoil that created the sawfly habitat. However, since that time the waterway has continued to be dredged periodically, most recently in the mid-1980's. The habitat at the type locality has recently been greatly altered by the removal of much of the sand. Most of the remaining habitat suitable for the sawfly lies in a narrow band at the south end of the spoil area.

This is probably the species discovered in the larval stage by W. McDearman, Museum of Natural Sciences, Jackson, Mississippi. According to McDearman (1990 in litt.) when he was at Gulf Shores, Alabama, in early November botanizing along the dunes, "I collected what appears to be sawfly larvae which were exclusively feeding on *Polygonella gracilis* (Nutt.) Meisn. (wireweed). The flowering period for these plants is a bit unusual—late summer and fall—from September through November. As with *Rhadinoceraea* [see Smith and McDearman 1990]—flowers were the primary food. These plants are indeed very slender and wiry with very little stem cortex (stem diameters rarely over 5 mm). I did not observe any indications that larvae emerged from eggs laid within the stem. I watched one larva disperse over a period of about an hour—but didn't see it burrowing in the soil to pupate. No adults were seen." In a subsequent letter, McDearman (1991 in litt.) stated that he returned to the coast in September 1990 hoping to find some larvae and adults on *Polygonella gracilis,* but was too early as few plants were in flower.

Adults were collected near the area McDearman made these observations, from *Polygonella gracilis* flowers, and were collected late in the year (mid-October) during the flowering time of the host (larvae were observed in November by McDearman). These pieces of circumstantial evidence strongly suggest that larvae of *A. autumnalis* feed on the inflorescences of *Polygonella gracilis.*

Polygonella gracilis is an annual of sandhills and occurs in the Coastal Plain from South Carolina to Florida west to Louisiana (Rickett 1967). The sawfly may have a much wider distribution but has escaped discovery because of its restricted habitat and late seasonal occurrence which is very unusual for sawflies.

ACKNOWLEDGMENTS

W. McDearman provided information on larval observations. Figure 5 was drawn by Linda Lawrence, staff artist, Systematic Entomology Laboratory, USDA. Cathy Anderson, Museum Technician, Systematic Entomology Laboratory, USDA, assisted with the final draft of the manuscript. The contribution by T.L. Schiefer was approved for publication as Journal Article No. J-9121 of the Mississippi Agricultural Experiment Station, Mississippi State University, with support from State Project MIS-6538. I thank the following for reviewing the manuscript: Henri Goulet, Agriculture Canada, Ottawa; Nathan N. Schiff, USDA, Stoneville, Mississippi; and N.E. Woodley and A.S. Menke, Systematic Entomology Laboratory, USDA, Washington, DC.

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TWO NEW SPECIES OF *ASYNDETUS* LOEW, AND NOTES ON THE IDENTITY OF *A. INTERRUPTUS* LOEW (DIPTERA: DOLICHOPODIDAE)

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Abstract.—***Asyndetus archboldi*** is described as new from the sand hills of peninsular Florida; ***A. wirthi*** is described from Jamaican and Antiguan material previously determined as *A. interruptus.* Observations are given on the type specimen of *A. interruptus* Loew in Havana, Cuba.

Key Words: *Asyndetus,* new species, Dolichopodidae, Florida, West Indies

Two new species of *Asyndetus* Loew are described, the first based on collections from the xeric uplands of Florida, and the second based on West Indian material previously identified as *A. interruptus* Loew.

The Florida *Asyndetus* is described and discussed as part of an effort to catalog the species of arthropods found in the Florida Scrub habitat. Florida scrub is a fire-maintained habitat that occurs on xeric sand ridges in scattered localities in Florida. The scrub habitat supports a number of species of plants and animals found nowhere else, and the rapid disappearance and degradation of the remaining areas lends an urgency to the project of cataloguing the resident arthropods. For more detailed descriptions of Florida scrub, see Myers (1990) and Abrahamson et al. (1984); for more information on Florida scrub arthropods, see Deyrup (1990) and Deyrup and Eisner (1993).

All specimens are presently deposited at either the National Museum of Natural History, Smithsonian Institution, (USNM) or the Archbold Biological Station (ABS).

Asyndetus archboldi Robinson and Deyrup, new species
(Figs. 1–3)

Holotype male.—Length 1.9 mm; wing 1.6 mm by 0.6 mm. Face 1.4 times longer than wide, sides parallel; face and front with dense silvery pollen. Palpus black, with several stout black setae; proboscis black; upper postocular setae black, lower postocular setae white. Antenna black, scape widened apically, without hairs or setae; pedicel about twice as long dorsally as ventrally in external lateral view, with a dorsal apical enlarged black seta; 1st flagellomere with a long, dorsal, sub-basal arista, encircled by a deep groove just distad of arista, so flagellomere appears divided into 2 parts.

Thorax dark gray with light gray pollen, with extremely faint greenish and coppery reflections when viewed in fluorescent light, with both green and coppery reflections conspicuous in incandescent light; all setae black; only 4 acrostichals in single irregular row, 4 pairs of dorsocentrals; 2 large scutellar bristles; 1 black proepisternal seta above fore coxa.

Coxa black, front and middle coxa with an anterolateral irregular row of bristles, hind coxa with an external basal bristle; femora black with conspicuous green reflections and yellowish apices; front and middle tibiae yellowish, hind tibia and all tarsi black; hairs and setae on legs black; middle and front tibiae with small seriate setae and single enlarged apical seta, hind tibia with paired anterodorsals and posterodorsals at basal fifth, at two-thirds and subapically; an unpaired anterodorsal at basal third. Front basitarsus with a subapical external cluster of small thick setae; 2nd, 3rd and 4th segments compressed, 5th segment depressed; pulvilli about as long as rest of 5th segment, claws about half as long as pulvilli, shorter than 3 apical bristles of 5th segment; lengths of tarsal segments from base: tarsus I, 0.30, 0.09, 0.06, 0.04, 0.05 mm, pulvilli 0.05 mm; tarsus II, 0.35, 0.16, 0.11, 0.08, 0.08 mm, pulvilli 0.03 mm; tarsus III, 0.25, 0.18, 0.12, 0.08, 0.08 mm, pulvilli 0.02 mm.

Wings appearing rather smoky due to dense, uniform microtrichae; veins dark brown; costa ending at apex of 3rd vein; 4th vein discontinuous, the "broken" ends apparently overlapping, at least as folds; calypter, its setae, and knob of halter, ivory.

Abdomen dark gray with thin gray pollen, with greenish and coppery reflections that are almost imperceptible in fluorescent light, conspicuous in incandescent light. Tergal setae black, suberect, apical band on each tergite larger; genital capsule with 4 large equal setae.

Allotype female.—Length 2.2 mm; wing 2.0 mm by 0.7 mm. Coloration, pollinosity, wing venation, tibial setae similar to male. Front tarsi not modified, setae of tergites shorter and more decumbent.

Holotype.—Male: FLORIDA: Highlands Co., Archbold Biological Station, 26 April 1996, M. Deyrup. On open sand at edge of fire lane, Florida scrub habitat (USNM).

Paratypes.—(USNM): 6 ♂, 3 ♀ (including allotype): same locality, date, collector, habitat as holotype; 1 ♀: same locality, collector as holotype, 30 Apr. 1989, road 6, scrubby flatwoods; 2 ♀: same locality, collector as holotype, 23 June 1989, white sand trail, scrub; 1 ♀: same locality, collector as holotype, 29 June 1989, white sand fire lane; 1 ♂, 1 ♀; 4 ♂, 15 ♀, same locality, collector as holotype, 16 June 1992, *inopina* scrub, line road; 1 ♂, 8 ♀: same locality, collector as holotype, 18 June 1992; 3 ♂, 3 ♀: same locality, collector as holotype, 19 June 1992; 1 ♂: same locality, collector, habitat as holotype, 18 Apr. 1996; 3 ♂, 7 ♀: same locality, collector, habitat as holotype, 23 Apr. 1996; 2 ♂, 1 ♀: same locality, collector, habitat as holotype, 24 Apr. 1996; 1 ♂: Lake Placid, Placid Lakes Development, 15 June 1992, M. Deyrup; same locality as holotype, 26 June 1989, R. Shumate, Malaise trap, *Ceratiola* area. (ABS): 9 ♂, 7 ♀: same locality, collector, habitat as holotype, 1 May 1996.

Etymology.—Named for the Archbold Biological Station, where most of the type material was collected.

Diagnosis.—Because of the pale fore tibia, black hind tibia, and the male face that is higher than wide, *Asyndetus archboldi* keys in Robinson (1964) to couplet 6, but differs from all the species in that part of the key by the small first flagellomere of the antenna. Relationship might be closest to some western species, particularly *A. latus* Van Duzee, from Bill Williams Fork, Arizona, having a similar densely silvery pollinose face and black palpi. The latter species is distinctly larger, ca. 3.5 mm long, is evidently from near water, and resembles other possibly related western species in having all the tibiae partly or wholly yellow (Van Duzee 1916, 1919).

Discussion.—Florida scrub habitat is the antithesis of habitats preferred by most Dolichopodidae: it is comparatively sterile, xeric, without nearby permanent water, with clumps of sclerophyllous, drought-adapted plants, and patches of bare, white sand. Other species of *Asyndetus* are usually found on the seacoast or around permanent fresh water (Cole 1969). However, *A. arch-*

boldi shares a habitat trait with some of its congeners: it is associated with sandy places. This is somewhat parallel to the situation in pygmy mole crickets (Tridactylidae) which live on algae growing in wet, sandy areas, except for a newly described species from Florida scrub (Deyrup and Eisner 1996). This latter pygmy mole cricket feeds on a recently discovered layer of algae that grows about 3 mm below the surface of the bare sand, where light is easily transmitted through the translucent grains and where atmospheric drying is much reduced. The larvae are known for only one species of *Asyndetus* (Williams 1938), that naturally occurs at the entrances of crab holes on sandy beaches, and whose larvae have been raised in vials where they were fed on drosophilid maggots. Almost all dolichopodid larvae are similarly predacious, but the animals on which they feed occur in a wide variety of habitats. At least some dolichopodid larvae are associated with algal mats (Oldroyd 1964). Thus, we speculate that the larvae of *A. archboldi* may be feeding in the algal layer under the sand on which the adults are found. The limited literature on dolichopid larvae and pupae (Willams 1938; Smith 1952; Dyte 1959; Robinson and Vockeroth 1981) would be augmented by discovery and description of the immature stages of *A. archboldi.*

Adults of *Asyndetus archboldi* occur on open sand at edges of fire lanes and in bare patches between clumps of scrub plants. These flies move quickly from place to place on the sand, seldom flying more than a few mm above the surface. They may perch for a few minutes on debris, especially the small dead leaves of scrub oaks. When individuals meet, they usually perform a rapid gyrating flight around each other, then separate. A fly can be captured by quickly placing a plastic bag over it, then chasing it up into the bag, where it can be sucked up with an aspirator. We have collected one specimen in a Malaise trap, but there seems to be no method for easily capturing large numbers of specimens at one time. We expect that, when dipterists begin to scan the surface of open sand for these tiny flies, that this species or similar species will be found in scrub elsewhere in Florida, and perhaps outside of the state as well.

Asyndetus wirthi **Robinson, new species**
(Figs. 4–6)

Holotype male.—Length 4.0 mm; wing 3.5 mm by 1.2 mm. Face ca. ¾ to ⅘ as wide as high, not recessed, white pollinose; front not noticeably wider than face at antennae, metallic greenish color almost totally obscured by grayish-white pollen. Palpus and proboscis black, the former with numerous black setae. Antenna black; pedicel only slightly produced above and on inner side, not longer above than below; first flagellomere scarcely as long as high, with very short, blunt point below arista, arista borne at distal ¼ of upper edge, very near tip. Lower postocular setae white.

Thorax mostly metallic green obscured with yellowish-gray pollen, with rather distinct brown pollinose stripe dorsally between rows of dorsocentrals; acrostichals distinctly biseriate; scutellum with small hair on lateral margin; with series of 5 or 6 small proepisternal setae above fore coxa of which those nearest the coxa are longer.

Legs dark, with some yellow at knees; coxae and femora metallic green with grayish pollen. Setae on anterior surfaces of coxae coarse, black. All femora with somewhat irregular series of anteroventral and posteroventral setae, half to three-fourths as long as widths of femora, a stouter anteroventral seta at tip of hind femur, 2 or 3 longer setae anterodorsally near tip of hind femur. Fore tibia with 2 or 3 anterodorsals, third and largest anterodorsal near middle, 1 distinct posterodorsal near middle, 2 small apicals above and below; middle tibia with 2 large anterior bristles near ⅕ and ⅗, small anterodorsal near ⅖, 3 rather small posterodorsals near ⅕, ⅖, and ⅗, 1 distinct ventral near ¾ and sometimes 1 smaller near ⅖, usually 5 large apicals; hind tibia with 7 anterodorsdals of irregular lengths staggered in 2 rows, basal in series very small, the second, fourth and sixth in a more anterior row and slightly larger, with 6 posterodorsals, the third and fifth large, near ⅖ and ¾, with 5 large apicals. Tarsus with last segment slightly broadened, all pulvilli enlarged and longer than 5th segment, fore tarsus slightly felted ventrally, middle basitarsus with only a few ventral spicules; lengths of tarsal segments from the base as: tarsus I, 0.52, 0.22, 0.17, 0.13, 0.17 mm, pulvilli 0.26 mm; tarsus II, 0.65, 0.35, 0.22, 0.17, 0.13 mm, pulvilli 0.24 mm; tarsus III, 0.48, 0.43, 0.30, 0.17, 0.13 mm, pulvilli 0.20 mm.

Wings grayish with yellowish-brown veins; anal margin fully rounded. Vein 1 reaching costa near middle of wing; vein 3 distinctly curved backward near tip; last part of vein 4 broken at bend, broken ends apparently slightly overlapping. Crossvein ¼ as long as terminal section of vein 5. Calypter, its setae and knob of halter whitish.

Abdomen metallic green dulled with gray pollen; hairs mostly short, hairs on sides and sternites longer, marginal setae 2 or 3 times as long as dorsal hairs. Genital capsule dark brown, bearing 4 stout bristles posteriorly.

Allotype female.—Length 4.0–4.5 mm; wing 3.5–3.9 mm by 1.3 mm. Face slightly higher than in male, with narrow clypeus visible; antenna as in male. Fore and middle coxae with setae less coarse anteriorly; femora without long setae or bristles below; hind tibia with small anteroventrals; last segments of tarsi not broader, pulvilli not enlarged.

Holotype.—Male, JAMAICA: Falmouth, bay shore, 1 March 1969, W. W. Wirth (USNM).

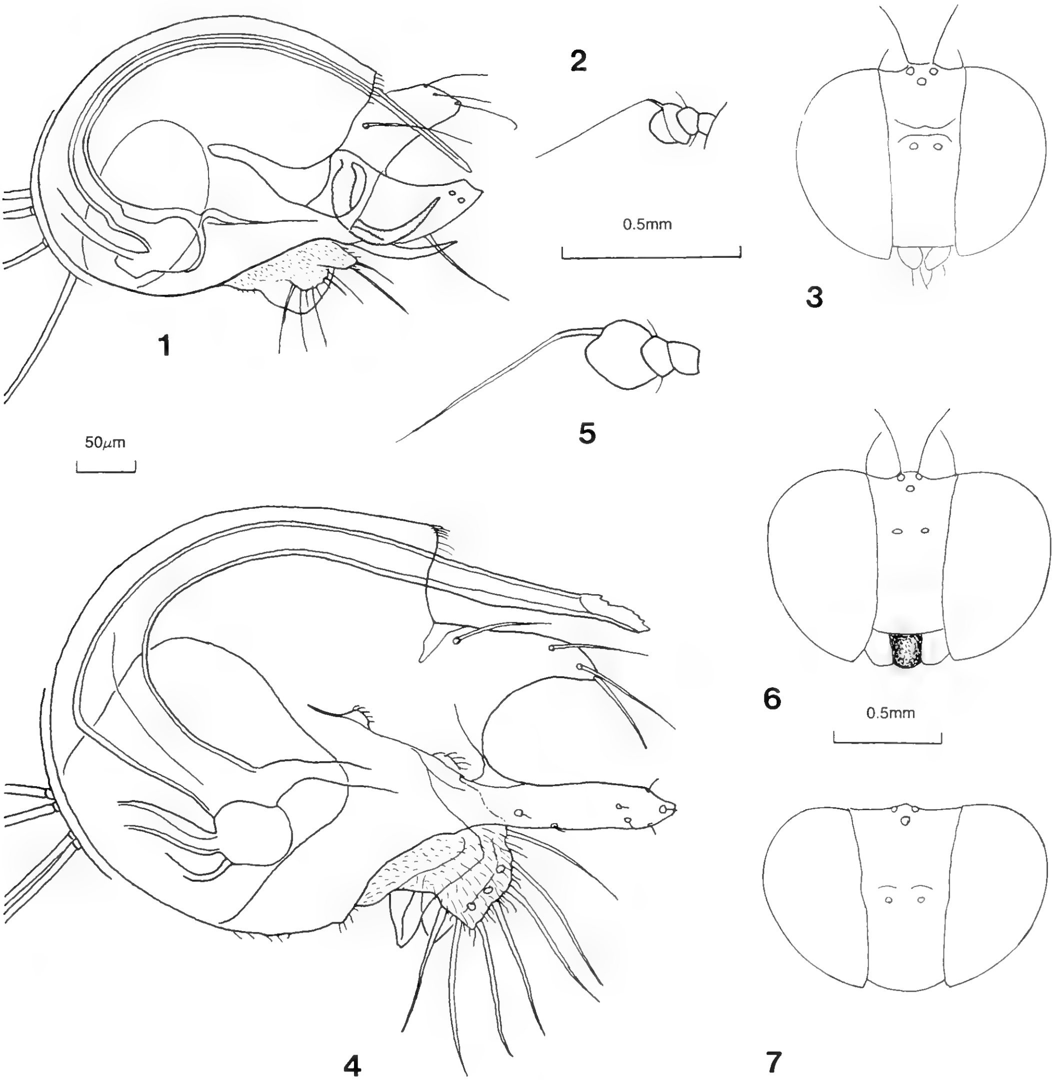
Paratypes.—3 ♂, 3 ♀ (including allotype): same locality, date, collector, habitat as holotype; 1 ♂, ANTIGUA: Dutchman Bay, 1 March 1969, W. W. Wirth (all USNM).

Etymology.—The species is named for the collector, the late Willis W. Wirth of the Systematic Entomology Laboratory, Diptera section of the U.S. Department of Agriculture.

Diagnosis.—*Asyndetus wirthi* differs from *A. interruptus* by the face of the male being higher than wide, very gradually narrowed from the front rather than having a slight but abrupt narrowing at the level of the antennae (Figs. 6, 7). The pedicel of the antenna has the upper edge scarcely longer than the lower edge, the first flagellomere is scarcely as long as high with a very short blunt point ventral to the arista, and the mesoscutum has brownish pollen between the rows of dorsocentrals. *Asyndetus interruptus* has the pedicel of the antenna distinctly longer above than below, the first flagellomere is swollen at the base with the lower edge oblique to a short and sometimes sharp point, and the mesoscutum is evenly grayish or whitish pollinose above.

Discussion.—The distinction between *Asyndetus wirthi* and *Asyndetus interruptus* Loew was first made by Robinson (1975). Unfortunately, at that time, *A. wirthi* was thought to be *A. interruptus,* and specimens of *A. interruptus* were described as a new species, *A. bredini.* The confusion was the direct result of inadequate knowledge of the type specimen of *A. interruptus,* supposedly deposited in the Poey collection in Havana, Cuba. The type was said to be in a sealed tray.

In 1990, this situation was resolved through a correspondent in Cuba, Gabriel Garcea G., who sent photographs of the type specimen. Garcea reported that the type was in the Gundlach collection of the Ecology-Systematics Institute, Academy of Sciences, in Havana, not in the Poey collection. The specimen is a male, with the genital capsule nearly hidden within the tip of the abdomen. The antennae are now missing from the type as depicted in the photographs, and the colors were said to be faded, but the head is present, and the frontal and facial shapes can be seen. The face is square, not higher than wide, the form previously cited for *A. bredini* Robinson



Figs. 1–7. *Asyndetus*. 1–3, *A. archboldi*. 1, Genital capsule. 2, Antenna. 3, Head showing face and front. 4–6, *A. wirthi*. 4, Genital capsule. 5, Antenna. 6, Head showing face and front. 7, *A. interruptus*, head showing face and front. 1, 4, 50 μm scale. 2–5, Upper 0.5 mm scale. 6, Lower 0.5 mm scale. 7, Drawn from photograph of type specimen, seen from slightly above.

(1975). *Asyndetus bredini* is a synonym of *A. interruptus*, and the material described as *A. interruptus* in 1975 is described here as a new species.

Both *Asyndetus wirthi* and *A. interruptus* are found along seashores of the Gulf of Mexico and Caribbean area, a habitat that is common in the genus. The new species is described strictly from Jamaica and Antigua, but it is presumed to occur more widely. A female, that may be this species, has been seen from Quintana Roo, Mexico. *Asyndetus interruptus* is known from Florida, Cuba and Dominica.

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CRINODESSUS AMYAE, A NEW NEARCTIC GENUS AND SPECIES OF PREDACEOUS DIVING BEETLE (COLEOPTERA: DYTISCIDAE: HYDROPORINAE: BIDESSINI) FROM TEXAS, U.S.A.

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Abstract.—***Crinodessus amyae*** n. gen. and n. sp. is described from southwestern Texas, U.S.A. The genus is separable from all other genera of Bidessini by the combination of 1) cervical line posterior of and separated from posterior margin of the eye, 2) separation of the genal line from the ventral margin of the eye broad, 3) apical segment of the paramere elongate, 4) dense microreticulation on the ventral surface consisting of minute, isodiametric cells, 5) relatively large size for members of the tribe, 6) distinctive habitus with the pronotum cordate and the body elongate and depressed, and 7) anterior clypeal margin extended anteriorly and prominently angulate. The similarity in habitus and other characters between *Crinodessus* and *Boongurrus* Larson is hypothesized to be a result of homoplasy due to similar behavior and common adaptation to a similar habitat. *Liodessus* Guignot is tentatively proposed to be the sister genus of *Crinodessus.*

Key Words: Taxonomy, predaceous diving beetle, Dytiscidae, new genus, Texas

Since Biström's (1988) review of the genera of the tribe Bidessini, two additional genera have been described, *Boongurrus* Larson (1994) from Queensland, Australia, and *Comaldessus* Spangler and Barr (1995) from Texas, U.S.A. Both are monotypic. The following new species from southwestern Texas cannot be satisfactorily placed into any existing genus of Bidessini. Therefore, a new genus is described herein to include it. The genus clearly belongs to the tribe Bidessini based on the presence of two-segmented parameres as defined by Biström (1988).

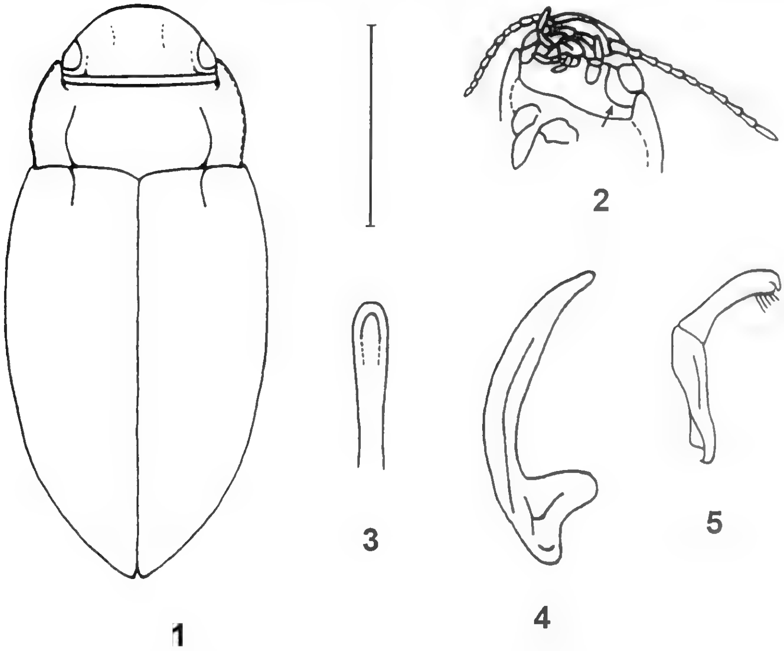
The following description follows the terminology and style of Larson (1994). Measurements were taken with the aid of an ocular micrometer in a Wild M3C dissecting microscope. Illustrations were made using a drawing tube mounted to a Wild M3 dissecting microscope.

Crinodessus Miller, new genus

Type species.—*Crinodessus amyae,* new species.

Diagnosis.—The combination of the following characters is diagnostic for *Crinodessus:* 1) Separation of the transverse cervical line and posterior margin of the eye; 2) separation of the genal line from the margin of the eye broad; 3) apical segment of the paramere elongate; 4) dense microreticulation on the ventral surface of the body consisting of minute, isodiametric cells; 5) relatively large size for members of the tribe; 6) distinctive habitus with cordate pronotum and elongate, depressed body; and 7) prominently anteriorly extended and angulate anterior clypeal margin.

Description.—Small, length 2.58 mm; body (Fig. 1) elongate; distinct discontinuity between pronotum and elytron in dorsal view; depressed. Color brown, slightly



Figs. 1–5. *Crinodessus amyae*. 1, Habitus. 2, Ventral surface of head, oblique view, showing genal line (indicated by arrow). 3, Median lobe of aedeagus, dorsal view. 4, Median lobe of aedeagus, lateral view. 5, Paramere, lateral view. Scale bar = 1 mm for Figs. 1 and 2 only.

darker on head and pronotum. Dorsal and ventral surfaces moderately punctate, ventral surfaces densely microreticulate.

Head: With clypeus prominently extended, forming angle with dorsal and ventral surfaces; with a distinct transverse line (cervical line) located between level of posterior margin of compound eye and margin of pronotum (Fig. 1), line relatively straight; eyes relatively small, head width between eyes/head width across eyes = 0.71; with a slightly depressed line near and parallel to posteromedial margin of eye; gena with distinct, curved line from posterolateral margin of head to lateral edge of base of maxilla (Fig. 2), region between eye and line impressed, more strongly so in anterior portion; apical palpomere of each palpus fusiform, apically bifid; antennomeres 2 and 3 subequal in length, antennomere 4, 0.6 length of 3, antennomeres 5–10 more rounded and broader anteriorly than posteriorly.

Pronotum (Fig. 1): In dorsal aspect with lateral margins strongly rounded, maximum width anterior to middle, lateral margin slightly sinuate basally with posterolateral angle acute, posterior margin evenly curved on each side of middle; lateral bead narrow and of equal width throughout; disc with sublateral, basal striae on each side of middle, stria extending about 0.6 length of pronotum measured along same general line as stria, stria slightly curved throughout length; lateral margin curved downwards on posterior angle. Scutellum not visible.

Elytron (Fig. 1): Without sutural stria; basal stria present, originating slightly medial to base of pronotal stria, about 0.5 length of pronotal stria, abruptly curved in basal 0.25, thereafter straight and approximately parallel to elytral suture; disc strongly flattened, without lateral grooves or ridges; epipleuron broad and visible to base in lateral aspect; not impressed basally, without oblique, transverse carina; gradually narrowed apically; evident to level of visible sternum 5. Hind wings present.

Prosternum: With anterolateral pore narrowly separated from anterior margin; with prominent, longitudinal, medial convexity extending from anterior margin and continuous with prosternal process; prominent setae on sides of convexity. Prosternal process in different plane than prosternum; blade of process ovate, laterally sharply margined, and setose; slightly convex in lateral aspect; apex barely reaching anteromedial lobe of metasternum, with minute spine directed posteroventrally.

Metasternum: Metacoxae and metasternum combined length about 0.33 length of body; metasternum with anteromedial process rounded, not grooved, entire surface moderately punctate without row of punctures laterad to midline; metasternal wing strongly arched and apically narrowed to epipleuron; metacoxal lines very lightly impressed, extending to metasternum, lines divergent from near base, slightly less than twice as long as distance between them at narrowest point; metacoxal processes depressed medially to level of abdominal sternum, each process with a minute, acute lobe extending over base of trochanter.

Legs: Profemur with arched apicoventral comb of yellow setae, its length about 0.21 length of profemur along ventral margin; maximum width of protibia 0.30 of its length, gradually widened from base to apex; anterior surface of protibia smooth and shiny with setae along margins; protarsomeres 1–3 broadly expanded, protarsomere 4 hidden in lobes of 3; metatrochanter 0.39 length of metafemur; metafemur with maximum width near middle, narrowed thereafter due to slight subapical convexity along posterior margin, slightly widened and rounded at apex; metafemur length 4.13 times greatest width; metatibia evenly widened apically, arcuate with point of greatest curvature about 0.4 length from base, ventrally and mesally with natatorial setae; metatarsus with natatorial setae, setae 1.38 times metatibial length.

Genitalia: Median lobe of aedeagus (Figs. 3, 4) simple, evenly arcuate in lateral aspect; lateral margins slightly divergent to rounded apex in dorsal aspect; paramere (Fig. 5) 2-segmented, apical segment about 0.79 length of basal segment, with a minute, hook-like apical projection. Female and larva unknown.

Etymology.—The masculine generic name is derived from the Greek word *crino,* "separate," referring to the separation between the cervical line and the posterior margin of the eye, and *dessus,* the suffix of the type genus of the tribe, *Bidessus* Sharp.

Discussion.—*Crinodessus* shares several characters with *Boongurrus* Larson including the elongate and flattened shape of the body, the cordate pronotum and the broad separation of the genal line from the margin of the eye. However, *Crinodessus* differs from *Boongurrus* in having an angulate anterior margin of the clypeus, an elongate apical segment of the paramere, and separation of the cervical line and the posterior margin of the eye. In addition, *Boongurrus* lacks microreticulation on the ventral surface, is more densely punctate and is smaller. It seems likely that the similarity between these genera is a result of homoplasy rather than close relationship. According to Larson (1994), small eyes, cordate pronotum, and elongate flattened shape are characteristic of species which live in substrate or move through interstices, the habitat of *Boongurrus* (Larson 1994) and the presumed habitat and behavior of *Crinodessus.* The broad separation of the genal line from the margin of the eye and separation of the cervical line from the eye in *Crinodessus* may have resulted from reduction in size of the eye and, partly, from elongation of the body. If *Crinodessus* and *Boongurrus* are closely related, it would be an unusual relationship given the broadly disjunct distribution of the two genera.

The simple shape of the genitalia along with the presence of a transverse cervical line and lack of sutural line on the elytra in *Crinodessus* indicate a possible sister-group relationship with *Liodessus* Guignot. *Crinodessus* keys to *Liodessus* in Young's

(1967) and Biström's (1988) keys to genera of Bidessini. However, *Crinodessus* differs from *Liodessus* in all of the above diagnostic characters except elongate apical segment of the paramere, a presumably plesiomorphic character (Larson 1994). The relationship between these two genera is, therefore, not well founded. However, *Crinodessus* shares no obvious affinities with any other genus.

Crinodessus amyae **Miller, new species**

(Figs. 1–5)

Holotype.—Male: labelled "TEXAS: Presidio County, 12 mi NE Ruidosa, Pinto Canyon, 23 October 1985, Rawlins & Davidson, legs./HOLOTYPE *Crinodessus amyae* K. B. Miller 1997 [red label]." Deposited in The Carnegie Museum of Natural History. Specimen dissected with genitalia in microvial of glycerin mounted on pin. According to R. Davidson (in litt.), the specimen was collected from a clear desert stream which flows over clean sand and gravel in the Chinati Mountains of southwestern Texas. The stream is about a meter wide with a few deeper pools.

Description.—*Measurements:* Length 2.58 mm; maximum width 1.19 mm; 2.17 times longer than wide, pronotum 0.85 times maximum width of body.

Color: Head brown, slightly darker brown anteromesad of each eye, slightly lighter on surface of frons and along margin of each eye; 4 basal antennal segments yellow, brown thereafter; palpi yellow-brown; pronotum brown, darker medially and gradually more pale laterally; elytra slightly lighter brown than head and pronotum, without maculations; ventral surface uniformly yellow-brown.

Sculpture: Head shiny, lightly shagreened and finely and evenly punctate; no punctures posterior to transverse line. Pronotum shiny, anterolateral surface slightly shagreened; moderately and evenly punctate; punctures larger than on head and separated by about 1.5 times puncture diameter except less dense mediad to apical half of each stria; slightly longitudinally rugulose mediad to base of striae. Elytron shiny and smooth; punctures similar in size and distribution to those of pronotum; punctation evident immediately adjacent to suture; slightly rugulose mediad to bases of striae. Epipleuron lightly shagreened and moderately punctate; punctures separated by 1.5–2.0 times puncture diameter and with short, decumbent setae. Metasternum, metacoxae and abdominal sterna with distinct microreticulation of minute, isodiametric cells covering entire surface; microreticulation less conspicuous on abdominal sterna.

Etymology.—I take pleasure in naming this species in honor of my friend and wife, Amy, who has been a source of great support during my studies of Dytiscidae.

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GALL MIDGE FORMS GALLS ON FRUIT FLY GALLS (DIPTERA: CECIDOMYIIDAE, TEPHRITIDAE)

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Abstract.—A cecidomyiid gall midge, *Rhopalomyia bigeloviae* (Cockerell), was reared from galls formed on galls of the tephritid, *Aciurina trixa* Curran, on *Chrysothamnus nauseosus* (Pallas) Britton in southern California. Only one of the two *A. trixa* gall types in southern California hosted the gall midge. *Rhopalomyia bigeloviae* galls were originally discovered in Colorado on the large cottony galls of *A. bigeloviae,* a species closely related to *A. trixa,* that forms galls on *C. nauseosus* outside of California. The midge galls are similar to the host tephritid galls externally, i.e. either smooth or cottony. The number of midge galls per tephritid gall varies, but they can, in some cases, cover the entire surface of the tephritid gall. The gall midge is probably bivoltine, and the tephritid host is univoltine. Gall midge galls first become visible in early spring (March). Adults emerge later in the spring. The fate of these adults remains unknown, but females may oviposit into other parts of the host plant to form a second generation of cecidomyiid galls not dependent on the presence of a tephritid gall.

Key Words: Gall formers, gall midge, Cecidomyiidae, Tephritidae, *Aciurina, trixa, Rhopalomyia, bigeloviae*

Aciurina trixa Curran forms axillary bud galls on branches of its only known host plant, *Chrysothamnus nauseosus* (Pallen) Britton, in western United States; but, the morphology of its gall varies strikingly within its range. In Idaho, at least three gall morphs of *A. trixa* were reported by Wangberg (1981); in southern California, we recognize two gall morphs for *A. trixa* on *C. nauseosus* (Headrick et al. 1997).

On one of the two gall forms in southern California (Fig. 1A), we observed that its exterior sometimes was covered by small nodules at different densities among different locations. Upon dissection, each of these nodules was found to contain a small cecidomyiid identified for us as *Rhopalomyia bigeloviae* (Cockerell) by Raymond J. Gagné (Systematic Entomology Laboratory, Agricultural Research Service, USDA). This species was originally described from a large woolly gall up to 12 mm long, typical of that made by another species of *Aciurina* (Gagné 1986). Dodson and George (1986) and Headrick et al. (1997) have clarified the status of *Aciurina* species on *C. nauseosus,* and this woolly gall is now attributed to the tephritid, *A. bigeloviae* (Cockerell). We have examined such woolly galls from various collections (Washington State University, Pullman; University of Idaho, Moscow; G. Dodson, personal collection) and they do, indeed, bear *R. bigeloviae* galls. None of the other gall types, as described by Wangberg (1981), examined from museum collections throughout western U.S., including the smaller resinous gall of *A. trixa* found in California hosted this gall midge (Headrick et al. 1997).

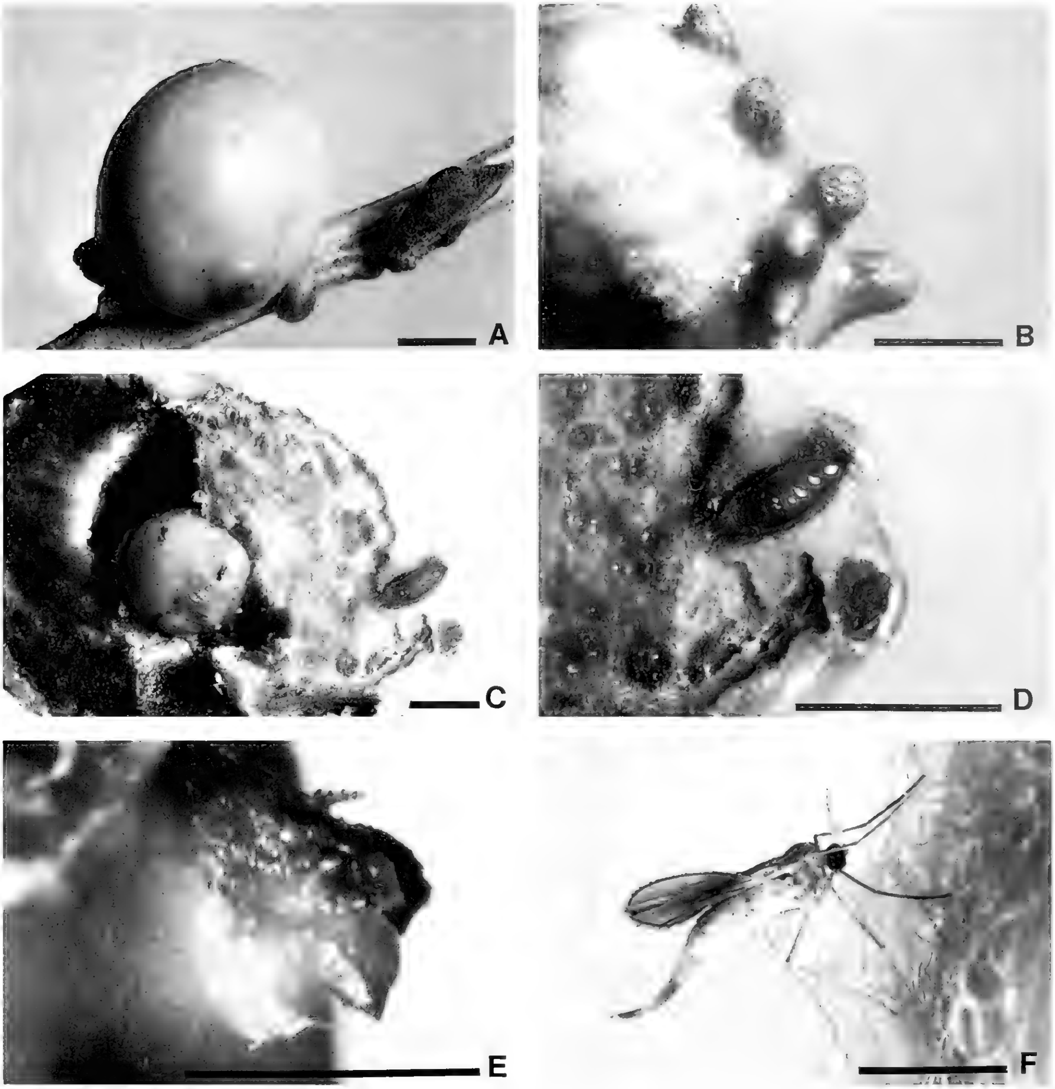

Fig. 1. (A) The fully formed gall of *Aciurina trixa* on *Chrysothamnus nauseosus*; (B) detail of the cecidomyiid, *Rhopalomyia bigeloviae,* galls on an *A. trixa* gall; (C) saggital section of *A. trixa* and *R. bigeloviae* galls; (D) detail of the *R. bigeloviae* gall with cecidomyiid larva within; (E) the exposed pupa of *R. bigeloviae*; (F) an adult female of *R. bigeloviae.*

In southern California, the midge galls become visible in early spring (March) and grow very rapidly (Fig. 1B), as do other *Rhopalomyia* spp. galls (Gagné 1989). The gall in saggital section is layered exactly like the tissues comprising the parent *A. trixa* gall, including the smooth, waxy, outer layer. On the cottony galls of *A. bigeloviae,* the midge galls also bear the thick tomentum of the host fruit fly gall, thus, the midge gall takes on the surface characteristics of the host gall. In southern California, the midge larvae feed within their gall locules as the tephritid larva continues to develop in its own, much larger, separate locule (Fig. 1 C, D). Midge development proceeds rapidly and both the tephritid and midge co-occur as late-instar larvae, and pupate at about the same time. The midge pupa forms inside its gall locule, but the waxy apex of its gall sometimes splits, partly exposing the pupa within (Fig. E). The gall midge adult emerges in April (Fig. F), but the fate of this generation remains unknown. We know that *A. trixa* is univoltine on *C. nauseosus,* with the gall dying after emergence of the fruit fly adult. Thus, the current season's tephritid galls are no longer suitable for oviposition by the midge. The options for the adult female gall midge following emergence include, but are not restricted to, oviposition into the primordial tephritid gall tissues or the axillary bud galls of the host plant or oviposition on another part of the host plant, thus cycling between alternate gall types. The latter appears likely as this has been reported for other species in this genus (Gagné 1989). There is as yet no indication that the cecidomyiid affects the growth and development of the tephritid and the relationship thus appears unequal, with the cecidomyiid dependent on the tephritid during this part of its life cycle.

This is the first known description and illustration of a cecidomyiid gall being formed upon a tephritid gall. Tephritids are known to be inquilines of cecidomyiid galls (Jones et al. 1983), but this is the most intimate association between gall-forming flies of these two families known to us.

Some workers may not have previously recognized this phenomenon and interpreted the growths on tephritid galls as developing leaves (Fernandez and Price 1994). This does happen, but closer inspection may otherwise reveal not a budding leaf, but rather a developing cecidomyiid gall!

Dedication.—We would like to dedicate this paper to Raymond J. Gagné in honor of his recent retirement from the Systematic Entomology Laboratory, U.S. Department of Agriculture.

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FOOD LIMITATION REDUCES BODY LENGTH IN MANTID NYMPHS, *TENODERA SINENSIS* SAUSSURE (MANTODEA: MANTIDAE): IMPLICATIONS FOR FITNESS

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Abstract.—Growth rate and body size have been linked to fitness in the mantid, *Tenodera sinensis* Saussure (Mantodea: Mantidae). We asked how early in the life cycle food level could affect these two parameters. Two laboratory cohorts were offered prey at either high or low density during first and second stadia. These nymphs exhibited significant differences in predation rate, growth rate, and body size, but not in gross growth efficiency. Well-fed nymphs achieved larger body size in a shorter time than poorly fed ones during both their first and second stadia. Because body size of adult females determines maximum fecundity, this response suggests that food level during the early life history of this species can directly affect fitness. Flexibility in body size and rate of development may play an important role in determining distribution and regional persistence of this species in temperate habitats.

Key Words: Body size, fitness, food limitation, growth, Mantidae, Mantodea, *Tenodera sinensis*

For generalist predators such as praying mantids, limited prey availability in nature is common, and can reduce growth, survival, and reproduction (Matsura 1981, Matsura and Marooka 1983, Hurd and Eisenberg 1984, Hurd et al. 1995). The impact of food limitation on growth and development would seem particularly acute for temperate zone mantids, that are faced with a limited growing season in which to complete their life cycles before freezing weather kills the adults.

Tenodera sinensis (Saussure) was introduced into this country in 1896 near Philadelphia, PA (Laurent 1898). It has since become a widespread and abundant mantid in the eastern United States, with a range extending from southern New England through the Carolinas (Rooney et al. 1996). This large-bodied species hatches from contagiously dispersed oothecae early in the spring, leading to dense concentrations of hatchlings when prey levels are low (Eisenberg and Hurd 1990). Low prey availability reduces both rate of development (Hurd and Rathet 1986) and survival (Hurd and Eisenberg 1984) during the early stadia. This is a semelparous, univoltine species which overwinters in the egg stage. Thus, reduced rate of development can retard maturation so that females do not have time to complete seven nymphal stadia, undergo oogenesis, and oviposit before killing frost (Hurd et al. 1995).

One consequence of early food limitation is reduced imago body length, and body length of adult females has been implicated as the limiting factor in egg production. Eisenberg et al. (1981) found that adult females with longer mean body length gained more mass in the field during oogenesis than those that had lower mean body length at a different site. Mass gain at this time of the life cycle is directly related to number of eggs contained in oothecae (Eisenberg et al. 1981, Hurd 1989). Thus, feeding condition of juvenile mantids can affect fitness (egg production) through body length. We asked how early in the life cycle the effect of food availability on components of fitness might be evident, by raising hatchling *Tenodera sinensis* in the laboratory at two prey abundance levels and recording body lengths at ecdysis and time spent in different stadia.

MATERIALS AND METHODS

Thirty-nine oothecae of *Tenodera sinensis* were collected early in the spring of 1996 from old fields in Rockbridge Co., Va. Four experimental groups of 20 nymphs each were established from individuals that hatched the same day. These groups were fed apterous *Drosophila melanogaster* (Meigen) at two levels and killed by freezing to measure and weigh after either the first or second molt.

Groups A and B were killed after the first molt. Nymphs in group A were fed four flies per day; those in group B were fed one fly per day. Groups C and D were killed after the second molt. Nymphs in group C were fed four flies per day; those in group D were fed one fly per day.

All nymphs were housed individually in 130-ml glass vials having tight lids fitted with fine-mesh brass screening for ventilation, and a hole through which a cotton swab, moistened daily with distilled water, was placed (Hurd and Rathet 1986). All vials were kept in a growth chamber set at 23°C and on a 16:8 (L:D) light cycle.

Body length, from front of head to tip of abdomen, was measured to the nearest 0.1 mm for all killed nymphs after thawing. Dry weight body mass was measured to the nearest 0.1 mg after drying in an oven at 50°C for 24 h. Number of days in a stadium was recorded for each nymph.

Because feeding rate can affect the efficiency with which food is processed by these predators (Hurd 1991), we calculated gross growth efficiency (GGE) for mantid nymphs in the first stadium, for groups A and B:

$$\begin{aligned}\text{GGE} = {} & [(\text{mass gained}) \\ & \div(\text{mass of food consumed})] \\ & \times 100\%\end{aligned}$$

where mass gained was individual mass of a nymph at ecdysis minus an established mean dry mass of 17 nymphs from the original cohort that had been killed, dried, and weighed upon hatching. Mass of food consumed was calculated by multiplying the number of flies eaten during a stadium by the mean dry weight mass measured from 50 flies taken from culture bottles at the beginning of the experiment. GGE could not be calculated for second stadium nymphs in C and D, because we had no baseline for beginning second instars from these two cohorts.

RESULTS

Mantids in both first and second stadia ate more, developed faster, and attained greater mean body length when fed four flies per day than when fed only one per day (Table 1). Group A and C nymphs fed at three to four times the rate of those in groups B and D, respectively.

Group B nymphs took about 50% longer to complete the first stadium than those in group A. The difference in rate of development was even more pronounced during second stadium: group D took nearly three times as long to complete the stadium as group C. In contrast, well-fed nymphs completed both first (A) and second (C) stadia in about the same time.

The percent gain in body length of well-fed nymphs compared to poorly fed nymphs increased from first to second stadium. Well-fed group A nymphs in first stadium attained a mean of 11% greater body length than poorly-fed group B individuals. For nymphs completing second stadium,

Table 1. Mean (±SE) predation rate (flies/day eaten), development time (days in stadium), and body length, for first and second stadium *Tenodera sinensis* nymphs, mean (±SE) percent gross growth efficiency (GGE) for first instars, and results of 2-tailed *t* tests for differences between pairs of groups. Calculation of GGE for first stadium nymphs explained in text. GGE was not significantly different between A and B after table-wide *P* adjustment for multiple comparisons (Rice 1989).

Group	Flies Eaten/Day	Days in Stadium	Body Length (mm)	%GGE
A	2.6 (±0.06)	8.3 (±0.13)	15.2 (±0.11)	30.8 (±0.99)
B	0.9 (±0.01)	12.1 (±0.39)	13.7 (±0.12)	27.4 (±1.24)
A v. B: t_{36} =	−29.83	−9.15	−9.02	−2.14
P =	≪0.001	<0.001	<0.001	0.04 (NS)
C	3.8 (±0.05)	8.2 (±0.14)	20.5 (±0.21)	
D	1.0 (±0.01)	22.8 (±0.74)	16.8 (±0.15)	
C v. D: t_{35} =	54.67	−19.96	13.88	
P =	≪0.001	<0.001	<0.001	

mean body length of group C nymphs was 22% greater than of those in group D. In fact, poorly fed group C nymphs completing second stadium (D) were hardly larger than well-fed group A nymphs completing first stadium.

Feeding level did not significantly affect GGE, though nymphs in group A were slightly more efficient on average than those in B (Table 1).

DISCUSSION

The benefit from increased feeding opportunity in *T. sinensis* nymphs occurred immediately after eclosion, in terms of both size and rate of development. The advantage in body size during first stadium increased during second stadium, indicating that the increased body size of well-fed first instars accumulates as individuals grow, at least through the second stadium. This could explain differences in adult body length (7–10 cm) in a given field population (personal observations). To the extent that body length determines maximum egg production, early feeding clearly can have a significant impact on fitness of females in this species.

Sex cannot be determined in *T. sinensis* until the third stadium, but sex ratio of hatchlings is 50:50 (Moran and Hurd 1994). However, although this means that half of our experimental animals were male, the effect of body size on male fitness has not yet been demonstrated.

The impact of feeding on development rate was also marked. For well-fed nymphs, the time to complete first and second stadia was about the same (8 days), although nymphs fed a single fly per day took nearly twice as long to complete second stadium as compared to first. Thus, well-fed nymphs took approximately 16 days (total) to complete the first two stadia; poorly fed nymphs, on the other hand, took more than 30 days to do the same thing. Our data suggest that well-fed nymphs could nearly complete four stadia in 30 days. This mantid is an ambush predator, and its nymphs do not move about very much in the field (Rathet and Hurd 1983). Thus, we feel it is unlikely that our nymphs expended significantly less energy in the vials (i.e., have more energy to grow) than they would have in the field.

Hurd (1991) found that %GGE varied with predation rate in first stadium *T. sinensis* nymphs: from 34% for <0.4 flies per day to 57% for 0.8 flies per day, reduced to about 40% for 1.2 flies per day. However, in the present experiment mean %GGE did not significantly differ between groups that ate 0.9 flies/day and those that ate 2.6 flies per day. In fact, %GGE was lower in this experiment than for any group in the earlier study. The design of this experiment was similar but there may have been a procedural difference, a genetic difference between these mantid nymphs and those used in the earlier study, or both that caused the disparity in results.

The degree of phenotypic flexibility of body size and rate of development exhibited by this species from the earliest stage of development has important implications for its distribution and persistence. Clearly, its latitudinal distribution will be limited to habitats of sufficient season length and feeding opportunity. However, the present contiguous distribution of this species in the eastern U.S. (approximately from southern Pennsylvania to northern Georgia) indicates a wide tolerance with regard at least to length of growing season. Because its body size is flexible, this species should be able to complete its life cycle under a variety of food levels. Thus, though early feeding experience can affect fitness in this species, flexibility in adult body length may partially mitigate the predicted shrinkage of regional distribution under global warming scenarios (Rooney et al. 1996).

The salient features of the life history of this mantid are shared by many other predacious arthropods inhabiting temperate seasonal environments. Our findings that adult fitness can be influenced by food availability immediately upon egg hatch may therefore be more general than for *T. sinensis*. However, we know of no comprehensive studies linking food limitation, growth rates, body size, and fitness in other such predators.

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NEW SPECIES OF SOUTHWESTERN NEARCTIC MICROCADDISFLIES (TRICHOPTERA: HYDROPTILIDAE)

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Abstract.—Four new species of Hydroptilidae are described and illustrated. ***Hydroptila abbotti* n. sp.** and ***Ochrotrichia boquillas* n. sp.** are known from the Austroriparian and Chihuahuan biotic provinces of Texas, respectively. ***Oxyethira garifosa* n. sp.** and ***Oxyethira desadorna* n. sp.** are described from northern Mexico. The new species are diagnosed with closely related congeners.

Key Words: Trichoptera, Hydroptilidae, microcaddisflies, Texas, Mexico, new species

Southwestern Nearctic caddisflies are poorly known. With recent concentrated survey efforts in Texas by Moulton and Stewart (in press) and sporadic collections in northern Mexico, species new to science continue to be discovered. This is especially apparent for the family Hydroptilidae. This paper describes four new species of microcaddisflies, one each in the genera *Hydroptila* and *Ochrotrichia,* and two in the genus *Oxyethira.* In North America *Hydroptila* is the most diverse hydroptilid genus with 110 species; *Ochrotrichia* and *Oxyethira* contain 72 and 40 species, respectively (Morse 1993). This family includes the smallest species of caddisflies, ranging from 1.5 to 5 mm. All of the material examined in this study was collected with an ultraviolet light trap.

Length is measured from the top of the head to the tip of the forewing. Holotypes are deposited in the National Museum of Natural History, Smithsonian Institution (NMNH). Paratypes are deposited in the NMNH, the Academy of Natural Sciences of Philadelphia (ANSP), the Illinois Natural History Survey (INHS), and the collections of the authors (SRM, SCH).

***Hydroptila abbotti* Moulton and Harris, new species**

(Fig. 1)

Hydroptila n. sp.: Moulton and Stewart, in press.

Description.—Length 2.0 mm. Brown in alcohol. 25 antennal segments. Segment VII with short ventromesal process, apex rounded in lateral view, triangular in ventral view. In lateral view, segment VIII somewhat triangular; in dorsal view, posterior margin incised. Segment IX short, retracted within segment VIII; in lateral view, anterior margin broadly rounded, narrowing posterad. Inferior appendages long, reaching to upturned portion of X; in lateral view, angled ventrad, ventral margin crenulate with apex pointed and heavily sclerotized; in ventral view, mesal margin ridge-like bearing four dark, stout points apically, several smaller dark points basally, broadest basally and narrowing towards shoulder-like apex. Segment X lightly sclerotized, approximately three times longer than wide; in dorsal view, widest in middle, apical one-third deeply bifurcate, tips of bifurca-

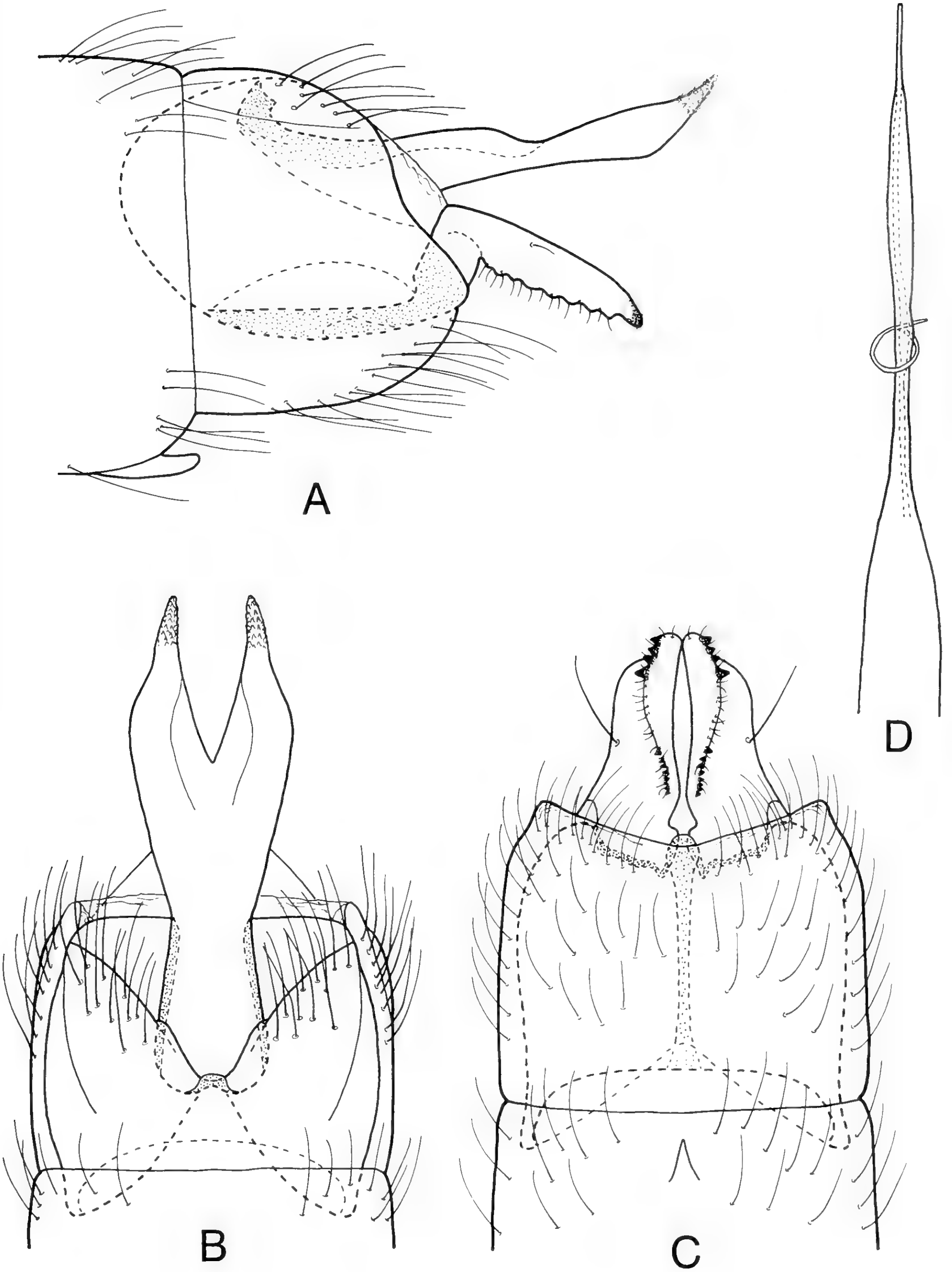

Fig. 1. *Hydroptila abbotti,* male genitalia. A, Left lateral view. B, Dorsal view. C, Ventral view. D, Phallus.

tions darkly pigmented and serrate; in lateral view, concave in middle, apices acute and angled dorsad. Phallus needle-like, basal one-quarter broadest; spiraled paramere making one revolution around shaft at midlength.

Immature stages and female.—Unknown.

Holotype male.—U.S.A.; TEXAS, Anderson Co., Skeet Branch, Engeling Wildlife Management Area, 3.2 km W Blackfoot, 12 June 1994, J. Abbott, J. Chirhart, M. Pasanante (NMNH).

Etymology.—Named for John C. Abbott, collector of the holotype.

Diagnosis.—This species belongs to the *H. waubesiana* group of Marshall (1979) and is most closely related to the recently described *H. homochitta* Harris and Sykora (Harris and Sykora 1996). *Hydroptila abbotti* is distinguished from the latter by the upturned, acutely tapered apex of tergum X in lateral view (club shaped in *H. homochitta*); the narrower base of tergum X in dorsal view, and the more developed apicolateral shoulder of each inferior appendage in ventral view. Additionally, unlike *H. homochitta, H. abbotti* does not possess a pair of long, thin intermediate appendages beneath tergum X.

Distribution.—Known only from the type locality in the east Texas Gulf Coastal Plain. This location is a first order, spring-fed, sand-bottomed stream. *Hydroptila abbotti* was collected along with *H. ouachita* Holzenthal and Kelley, a species previously known only from Schoolhouse Spring, Jackson Parish, Louisiana (Holzenthal and Kelley 1983), approximately 480 km east of the Texas collection locality. Both of these locations have similar habitat characteristics.

Ochrotrichia boquillas Moulton and Harris, new species

(Fig. 2)

Ochrotrichia n. sp.: Moulton and Stewart, in press.

Description.—Length 2.5 mm. Brown in alcohol. 29 antennal segments. Segment VII with short, acute ventromesal process. Segment VIII rectangular in dorsal and lateral views. Segment IX in lateral view with posterior margin broadly rounded; anteroventral margin produced slightly into segment VIII. In lateral view, inferior appendages lobate, curving dorsad; in ventral view, bases broad, ventromesal surfaces shoulder-like in middle, diverging towards apices, each lined with comb-like row of erect, stout setae; apices with row of longer, hair-like setae. In dorsal view, segment X spatulate, rounded on apex; wedge-shaped in lateral view; basodorsal area bearing two sclerotized processes, left process V-shaped, right process ventrolaterally hooked. Phallobase flared, tapering towards middle; apical one-half nearly parallel sided; apex with prominent ejaculatory duct emerging from middle, encircled preapically by acute, sclerotized process.

Immature stages and female.—Unknown.

Holotype male.—U.S.A.; TEXAS, Brewster Co., Glenn Spring, Big Bend National Park, 18 April 1993, R. Garano (NMNH).

Paratypes.—Same as holotype, but Rio Grande Village Campground, 2 April 1993, J. Gelhaus and D. Koenig, 4 ♂ (ANSP); Val Verde Co., Dolan Creek at Penstemon Cliff Springs above confluence Devils River, 27-28 July 1995, G. Easley, 1 ♂ (NMNH).

Etymology.—Named for Boquillas Canyon, through which the Rio Grande flows near the Big Bend area of Texas and Mexico.

Diagnosis.—*Ochrotrichia boquillas* is a member of the *O. xena* group (Flint 1972) and is most closely related to *O. flagellata* Flint and *O. pectinata* Flint. *Ochrotrichia boquillas* differs from these species by the lobate structure of the inferior appendages in lateral view and the configuration of spinous processes on tergum X.

Distribution.—Known only from the localities of the type material.

Oxyethira garifosa Moulton and Harris, new species

(Fig. 3)

Description.—Length 2.8 mm. Brown in alcohol. 40 antennal segments. Segment VII

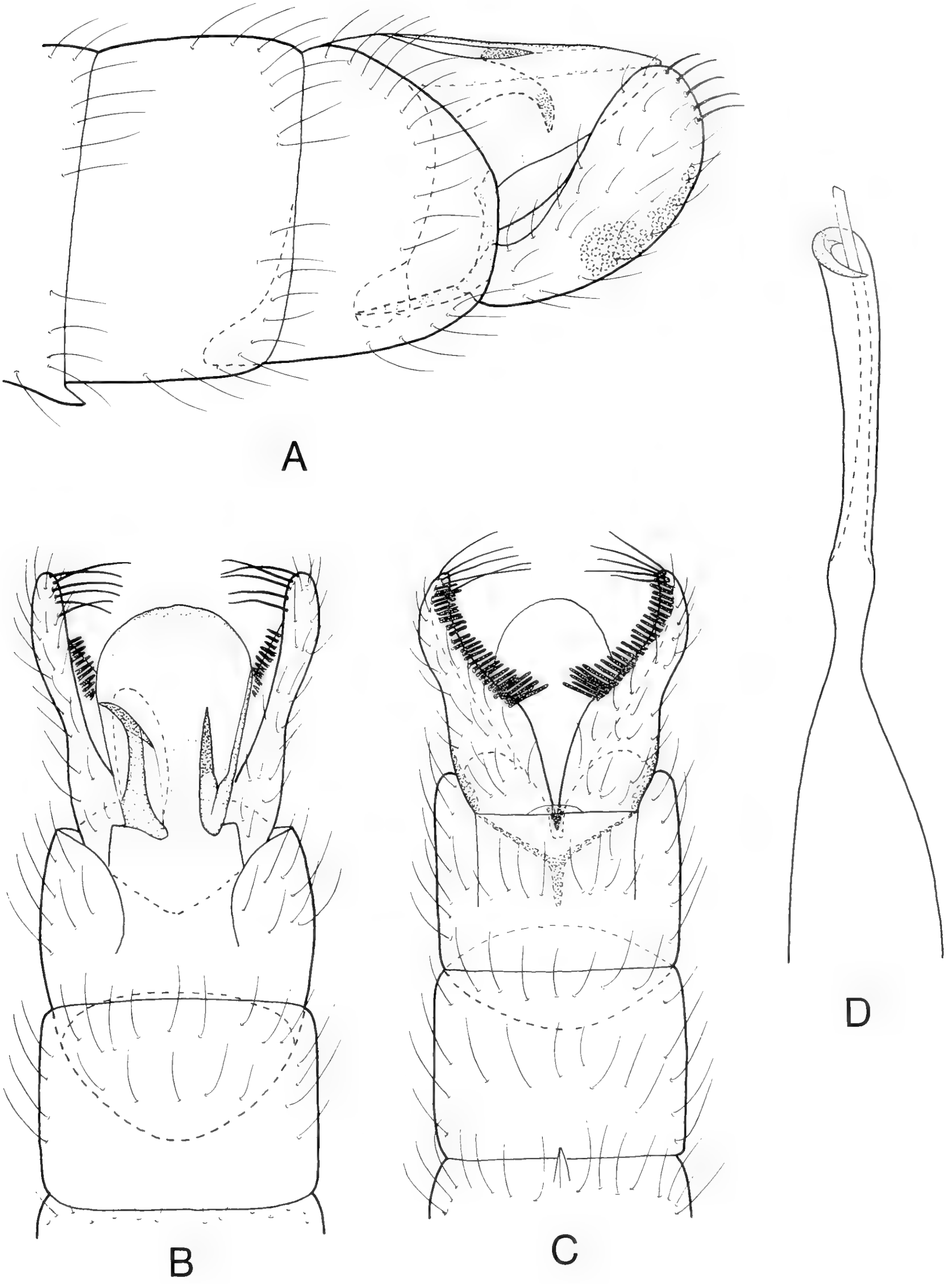

Fig. 2. *Ochrotrichia boquillas,* male genitalia. A, Left lateral view. B, Dorsal view. C, Ventral view. D, Phallus.

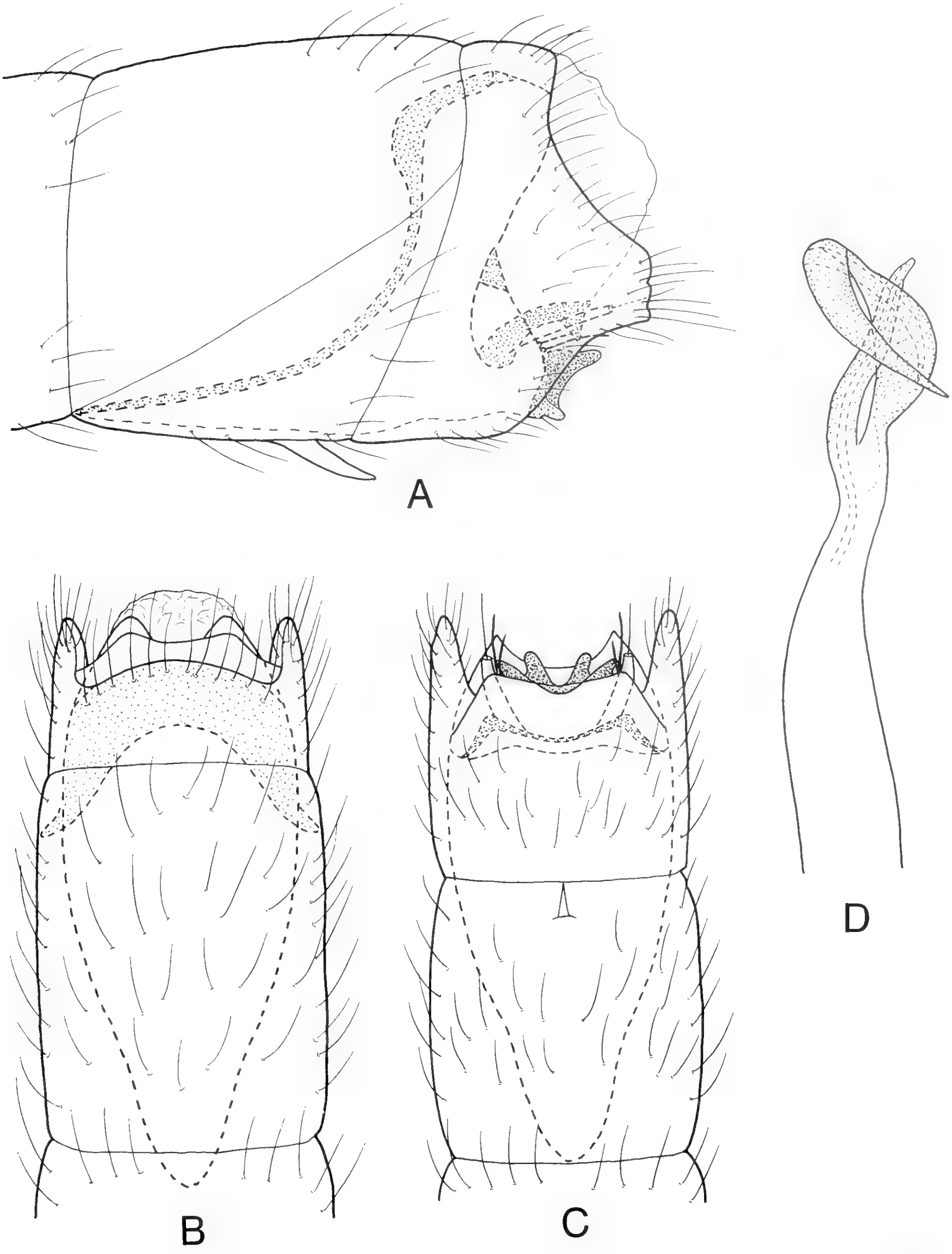

Fig. 3. *Oxyethira garifosa,* male genitalia. A, Left lateral view. B, Dorsal view. C, Ventral view. D, Phallus.

with short, acute ventromesal process. Segment VIII with lateral margins produced posterad, apex truncate, slightly scalloped; dorsal and ventral margins broadly emarginate. Segment IX complete dorsally and concealed within segments VII and VIII, anterior one-half extending to posterior margin of segment VI, posterior margin sinuate with broad lobe ventrally bearing several stout setae. Tergum X membranous in lateral view; rectangular in dorsal view. Inferior appendages fused: in lateral view, dorsal margin twice as long as ventral margin, concave on posterior margin; in ventral view, appearing as four lobate processes. Subgenital plate narrow in lateral view, distally with acute ventral tooth; narrowing mesally in ventral view, sclerotized along posterior margin. Bilobed processes widely separated in ventral view. Phallobase tubular, tapering in middle; apical one-half divided into two sclerotized processes, shorter process sinuate, apically acute, longer process broadest basally, constricted and twisted in middle, recurving to an acute apex.

Immature stages and female.—Unknown.

Holotype male.—MEXICO; TAMAULIPAS, Municipio de Ciudad Victoria, Arroyo los Troncones, Ejido La Libertad, ca. 10 km NW Victoria, 14 May 1989, S. Harris, A. Contreras, and A. Moreno (NMNH).

Etymology.—Spanish; hook-like, referring to the distinctive phallic structure.

Diagnosis.—This species fits within the *Damphitrichia* subgenus in the *pallida* group as established by Kelley (1984) based upon the complete dorsum of segment IX and the absence of a spiraled paramere on the phallus. The new species is most similar to *O. arizona* Ross and *O. verna* Ross in overall appearance. From the former, *O. garifosa* is distinguished by the absence of dorsolateral processes on segment VIII, and from the latter, the new species is distinguished by the hooked phallus and lobate processes of the inferior appendages.

Distribution.—This species is known only from the type locality in northern Mexico.

Oxyethira desadorna Moulton and Harris, new species

(Fig. 4)

Description.—Length 2.0 mm. Brown in alcohol. 28 antennal segments. Segment VII with short, acute, ventromesal process. Segment VIII subrectangular in lateral view, posterior margin convex in middle; dorsal margin with shallow, wide emargination; ventral margin with deep, V-shaped excision. Segment IX complete dorsally and concealed within segments VII and VIII; in lateral view, anterior three-quarters wedge-shaped, extending to middle of segment VII. Tergum X fused with IX; nearly circular in dorsal view, posterior margin with wide concavity. Subgenital plate thin and elongate in lateral view, strongly curved ventrad; in ventral view plate-like with emarginate posterior margin, bearing pair of setae posterolaterally. Inferior appendages fused; triangular in lateral view with pair of internal processes, lower process heavily sclerotized and upper process tubular, bearing setae distally; posterior margin with broad, emargination in ventral view, pair of setal bearing processes projecting from dorsal surface. Phallus tubular; apex semimembranous and club-like, bearing single, curved sclerotized process.

Immature stages and female.—Unknown.

Holotype male.—MEXICO; NUEVO LEON, Municipio de Santiago, spring along road above Cola de Caballo, 27 May 1991, S. Harris and A. Contreras (NMNH).

Paratypes.—NUEVO LEON, Municipio de Sanchez, Arroyo San Juan on road to Laguna de Sanchez, 3.5 km W La Cienegra, 13 May 1989, S. Harris and A. Contreras, 56 ♂ (NMNH, INHS, SRM, SCH); TAMAULIPAS, Municipio de Gomez Farias, Rio Frio at La Poza Azul, 6 km S Gomez Farias, 7 August 1988, A. Contreras and A. Moreno, 1 ♂ (NMNH).

Etymology.—Spanish; unadorned, referring to the simple appearance of the male

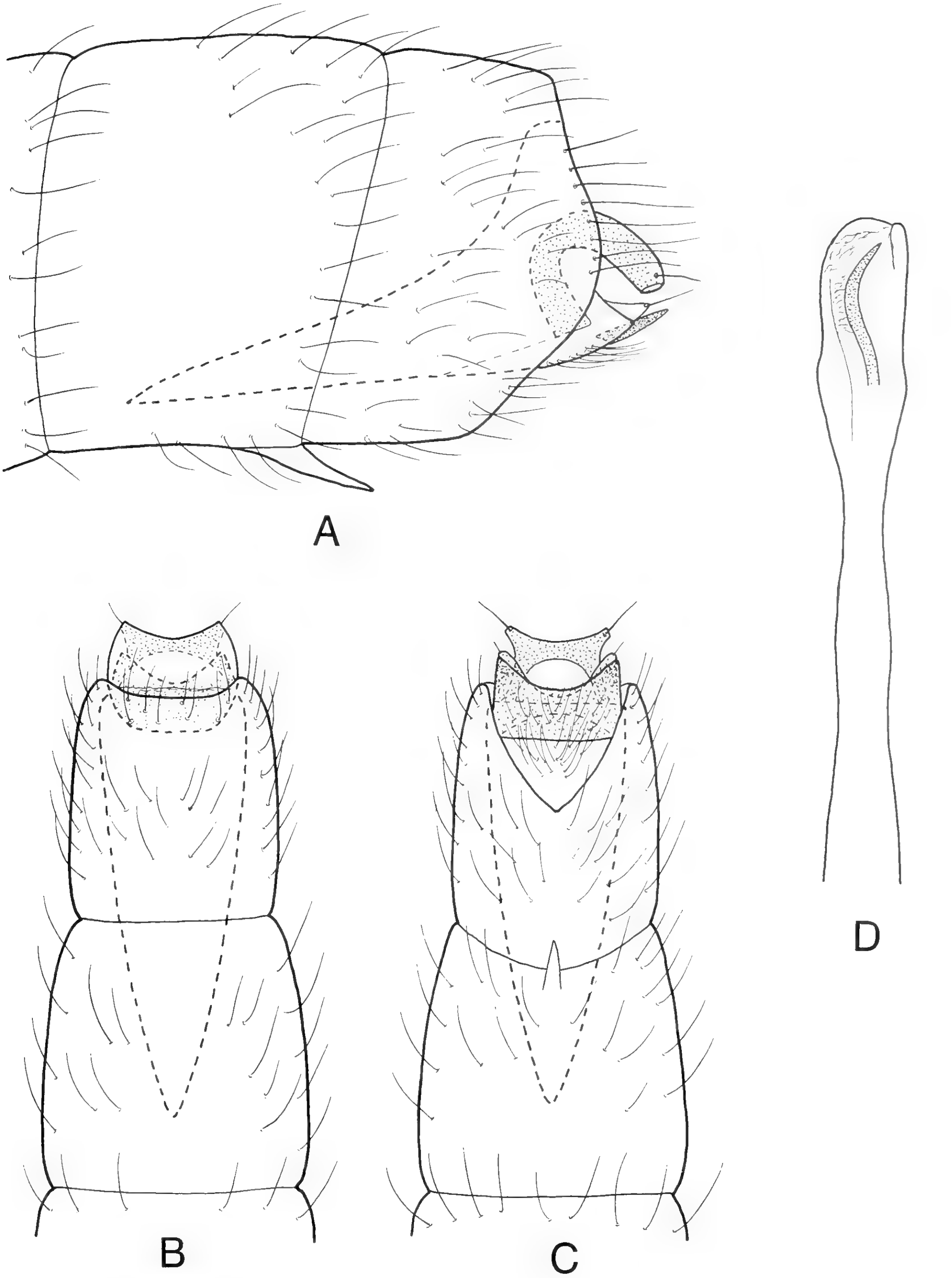

Fig. 4. *Oxyethira desadorna,* male genitalia. A, Left lateral view. B, Dorsal view. C, Ventral view. D, Phallus.

genitalia and the absence of distinctive accessories.

Diagnosis.—This species appears to be most similar to *O. unispina* Flint and other members of the *Oxytrichia* subgenus as defined by Kelley (1984). As in *O. unispina,* the phallus of *O. desadoma* has a narrow, sinuate spine. However, the new species is distinguished by its concave subgenital plate and the absence of lateral extensions from IX in lateral view.

Distribution.—Known only from the localities of the type material in northern Mexico.

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A NEW GENUS AND A NEW SPECIES BELONGING TO THE SUBFAMILY BLENNOCAMPINAE (HYMENOPTERA: TENTHREDINIDAE) FROM JAPAN

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Abstract.—**Nipponostethus imperialis,** n. gen., n. sp., from Japan are described and illustrated. The new genus is closely related to *Megatomostethus,* and characters are given to distinguish the two genera.

Key Words: *Nipponostethus,* Blennocampinae, Tenthredinidae, sawfly, Japan

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Recently, I studied eight specimens of the subfamily Blennocampinae closely allied to the genera *Megatomostethus* Takeuchi and *Habachia* Takeuchi. They differ from these two genera by characters of the malar space, the prepectus, the claw, and the postorbital groove (Takeuchi 1952, Okutani 1972). Therefore, I believe they represent a new genus. In this paper, I describe and illustrate this new genus and species.

Nipponostethus Togashi, new genus

Body rather robust. Labrum rather small (Fig. 3); front margin of clypeus slightly emarginate (Fig. 3); malar space broad (Fig. 2); postorbital groove distinct (Fig. 2); postorbital carina present, developed below eye (Fig. 2); antenna filiform, 3rd segment longer than 4th and segments 3–8 more than 2× longer than broad (Fig. 4); prepectus present as raised shoulder, separated from mesepisternum by furrow (Fig. 5); forewing with 4 cubital cells, stub of analis straight (Fig. 6); hindwing with a middle cell and petiolate anal cell (Fig. 7); inner tibial spur of fore leg cleft at apex (Fig. 8); tarsal claw with inner tooth and basal lobe (Fig. 10).

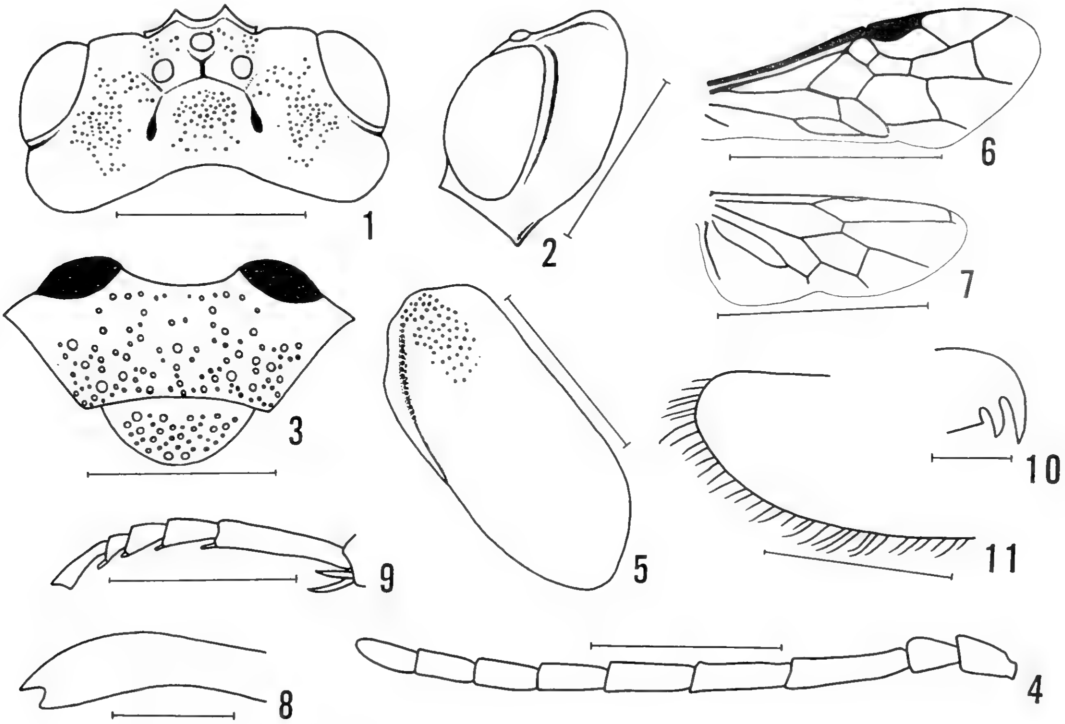
Type species: *Nipponostethus imperialis,* new species. This new genus is very closely allied to the genus *Megatomostethus* Takeuchi, but it can be easily distinguished from the latter by the presence of the broad malar space (in *Megatomostethus,* the malar space is linear or sometimes absent) and the long slender antenna (in *Megatomostethus,* the antenna is stout with segments 3–8 not much longer than broad).

From *Habachia* Takeuchi, it is easily separable by the small labrum (in *Habachia,* the labrum is large and elongate); by the presence of the prepectus (in *Habachia,* the prepectus is absent); by the presence of the large inner tooth and basal lobe of the claws (in *Habachia,* the claw have a minute inner tooth and no basal lobe); and by the presence of the postorbital groove (in *Habachia,* the postorbital groove is absent).

Nipponostethus imperialis Togashi, new species
(Figs. 1–12)

Female.—Length 7–7.5 mm. Head and thorax black but apex of mandible reddish brown; antenna entirely black; wings slightly infuscate, stigma and veins black; legs entirely black. Abdomen reddish brown, with propodeum and sawsheath black.

Head: From above transverse (Fig. 1); OOL:POL:OCL = 1.2:1.0:1.6; postocellar area convex; interocellar and postocellar furrows distinct but rather shallow; lateral



Figs. 1–11. *Nipponostethus imperialis.* 1, Head, dorsal view. 2, Head, lateral view. 3, Clypeus and labrum, front view. 4, Antenna, lateral view. 5, Mesopleuron, lateral view. 6, Forewing. 7, Hindwing. 8, Inner foretibial spur, lateral view. 9, Hind tarsus, lateral view. 10, Tarsal claw. 11, Sawsheath, lateral view. Figs. 1, 2, 4, 5, 9, scale = 1.0 mm; Figs. 3, 11, scale = 0.5 mm; Figs. 6, 7, scale = 5.0 mm; Figs. 8, 10, scale = 0.1 mm.

furrows distinct and deep (Fig. 1); frontal area evenly concave, with a low surrounding wall; median fovea distinct, large, and rather circular in outline; lateral foveae distinct and elongate; supraclypeal area rather flattened; antenno-ocular distance slightly longer than distance between antennal sockets (ratio about 1.0:0.9). Clypeus convex; labrum nearly flattened; malar space broad, but nearly ½ as long as diameter of front ocellus (ratio about 1.0:2.0).

Antenna slightly shorter than costa of forewing (ratio about 1.0:1.1), relative lengths of segments about 1.3:1.0:2.3:1.8:1.7:1.4:1.2:1.1:1.2; pedicel longer than width (ratio between length and width about 1.0:0.7).

Thorax: Mesopraescutum prominently raised; mesoscutellum nearly flattened; cenchri large, distance between them as long as breadth of one. Wing venation as in Figs. 6 and 7. Hind basitarsus longer than following 3 segments combined (ratio about 1.0:0.8); inner fore tibial spur as in Fig. 8; claw as in Fig. 10.

Abdomen: Normal; sawsheath as in Fig. 11; lancet with 16 serrulae (Fig. 12).

Punctation: Head except for clypeus and labrum covered with fine setigerous punctures; clypeus and labrum largely and rather irregularly and closely punctured (Fig. 3); pronotum, mesonotum and scutellum covered with fine setigerous punctures; posterior margin of mesoscutellum closely and striately sculptured; lateral sides of posttergite distinctly punctured; front and upper portion of mesopleuron moderately and rather closely punctured; mesosternum nearly impunctate. Abdominal tergites shagreened.

Male.—Unknown.

Food plant.—Unknown.

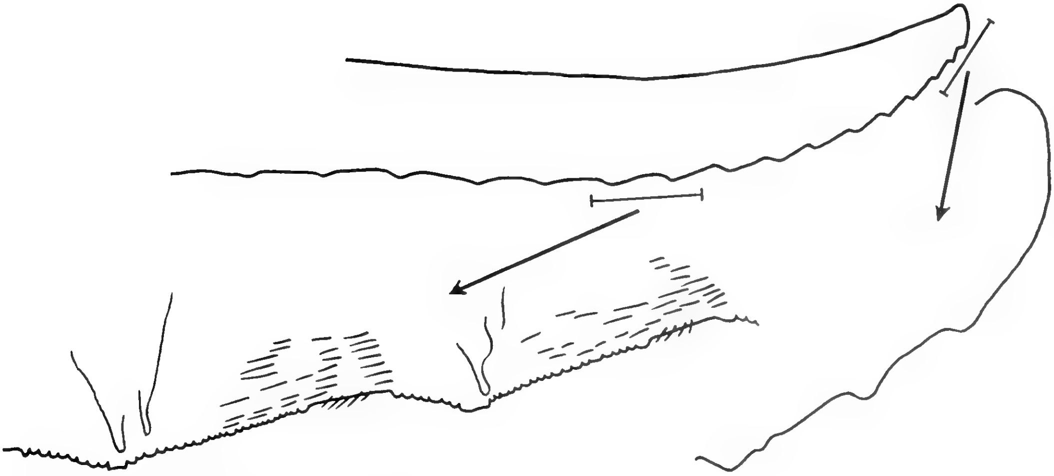


Fig. 12. *Nipponostethus imperialis,* lancet.

Habitat.—Japan (Honshu and Shikoku).

Holotype.—Female, 18. IV. 1996, Imperial Palace, Fukiage Gyoen, Tokyo Pref., A. Shinohara leg. Deposited in the collection of the National Science Museum (Nat. Hist.), Tokyo.

Paratypes.—3 ♀, 12. V. 1973, Mt. Ioo, Ishikawa Pref., T. Mikage leg.; 1 ♀, 5. V. 1979, Mt. Kaji, Kochi Pref., T. Nishida leg.; 1 ♀, 24-26. VII. 1980, Minoto, Mts. Yatsugatake, Nagano Pref., A. Shinohara leg.; 1 ♀, 22. VII. 1989, Yarisawa (alt. 1600–1900 m), Kamikochi, Nagano Pref., A. Shinohara leg.; 1 ♀, 26. IV. 1992, Hikagezawa, Mt. Takao, Tokyo Pref., A. Shinihara leg. Two paratypes are deposited in the Smithsonian Institution, Washington, D.C., four paratypes are deposited in the collection of the National Science Museum (Natural History), Tokyo, and other one in my collection.

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A FIRST RECORD OF *APTILOTUS* MIK (DIPTERA: SPHAEROCERIDAE) FROM THE NEOTROPICAL REGION, WITH THE DESCRIPTION OF THREE NEW WINGLESS SPECIES OF THE *APTILOTUS PARADOXUS* GROUP FROM HIGH ELEVATIONS IN COSTA RICA

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Abstract.—The genus *Aptilotus* Mik is recorded from the Neotropical Region for the first time. ***Aptilotus nigritibia,* new species, A. *nigrimera,* new species, and *A. zumbadoi,* new species**, all completely wingless, are described from *ca.* 3,000 m in Costa Rica. A key to the Costa Rican *Aptilotus* is provided.

Key Words: Diptera, Sphaeroceridae, Limosininae, wing loss, zoogeography, taxonomy, Costa Rica

The genus *Aptilotus,* named for the single wingless European species, *A. paradoxus* Mik, is a primarily Holarctic group in which wing reduction has occurred independently within at least five lineages (Marshall 1983, Marshall and Smith 1990). Twelve described species of *Aptilotus* are Nearctic, one species is described from Europe, one is described from Ethiopia, four are from Nepal, two are from southeast Asia, and a group of seven closely related species are restricted to the Canary Islands. There were no known Neotropical *Aptilotus* prior to the discovery of the three new wingless species described herein, all of which are endemic to high elevation sites in Costa Rica.

Aptilotus species can be apterous, brachypterous, or polymorphic for wing development, with aptery having evolved independently in each of the species groups recognized by Marshall (1983). The genus can be diagnosed by the following characters: male with a translucent, usually quadrate posteromedial lobe on sternite 5; body usually black, shining and punctate; female tibia with only an apical bristle; dorsocentral bristles in 2 pairs but anterior pair often small; surstylus of characteristic shape, divided into an outer setose part and an inner part with 1 or (usually) 2 stout bristles.

All known Central American *Aptilotus* can be distinguished from other wingless Central American Sphaeroceridae not only by the defining characters of *Aptilotus* as outlined above, but also by the plesiomorphic possession of two orbital bristles. Other wingless Central American sphaerocerids, most of which belong to the genus *Pterogramma,* have only a single orbital bristle.

RELATIONSHIPS

The species described here belong to the *paradoxus* group of Marshall (1983) with which they share the following synapomorphies: distiphallus elongate, comprised of distinctive dorsal and ventral loops and a broad, bilobed membranous and microspinulose apex; outer posterior part of surstylus long-setose; anterior surstylar spur characteristically flattened, often scale-like. Delimited on the basis of these characters, the *paradoxus* group includes a clade of 6 brachypterous and one macropterous species restricted to the Canary Islands (*A. beckeri* and related species), an apterous European species (*A. paradoxus* Mik), three macropterous species from Nepal (*A. glabrifons* Marshall, *A. spinistylus* Marshall, *A. rufiscapus* Marshall), two macropterous eastern North American species (*A. pogophallus* Marshall and *A. nigriphallus* Marshall), a macropterous species in Japan (*A. longinervis* Hayashi), a dimorphic western North American species (*A. luctuosus* (Spuler)) and two brachypterous western North American species (*A. nigriscapus* Marshall, *A. luteoscapus* Marshall). The new Costa Rican species all seem to be closely related to a clade including European and western North American species which have relatively short female cerci and quadrate, bilobed posteromedial areas on male sternite 5.

Although all *Aptilotus* exhibit an unusual degree of morphological uniformity, the Costa Rican species seem to represent a distinct clade, weakly supported on the basis of the shape of sternite 5 of the male, the sclerotized part of which is very short medially, and sternite 8 of the female, which is reduced and modified. Within the Costa Rican *Aptilotus* clade, *nigrimera* plus *zumbadoi* form a monophyletic group, strongly supported by the possession of a third surstylar bristle and the loss of bristles from tergite 9 of the female.

DISCUSSION

All of the species described here were collected on Cerro de la Muerte, at a cold paramo-like site at 3300 m, or in high elevation forests (2600 m and above) within a few kilometres of Cerro de la Muerte. Although it seems likely that related species occur, or previously occurred, at other relatively high elevation sites in the intervening area, current data show a disjunction between the cluster of endemic *Aptilotus* in Costa Rica and their nearest relatives in western North America. Other high elevation collections in Costa Rica have yielded wingless Sphaeroceridae, but only in primarily Neotropical clades related to *Pterogramma* Spuler. Similarly, sphaerocerid samples available from leaf litter collections from other high-elevation Central American sites have included a diversity of undescribed *Pterogramma* but no *Aptilotus*. Habitat at these sites ranged from mixed oak-pine forests at 2800 m (Oaxaca, Mexico) to high elevation cloud forests at elevations from 2300–2800 m (Chiapas, Mexico; Quezaltenango, Guaemala; El Salvador; Cerro Chiriqui, Panama). Also, no South American *Aptilotus* are known, despite collection efforts in apparently suitable habitat in the paramos of Ecuador and Venezuela.

Despite the lack of Mexican and Central American records outside Costa Rica, further sampling at higher elevations than those sites from which samples are currently available are likely to reveal additional *Aptilotus* species. It is hypothesized that *Aptilotus* is a primarily northern group, present in the Neotropical region as far south as lower Central America (but not into South America), where it exhibits a highly disjunct distribution restricted to cool temperate conditions at elevations above 2500 m.

KEY TO THE COSTA RICAN SPECIES OF *APTILOTUS*

1. Legs mostly black, trochanters and mid and hind tarsi brown; antenna black. Female sternite 8 very small, transverse (Fig. 14). Female tergite 9 with two bristles (Fig. 16). Surstylus with 2 short, thick ventral bristles (Fig. 11) . . . . *Aptilotus nigritibia,* n. sp.
– Legs luteous, antenna variable. Female sternite 8 with an elongate anterior portion (Figs. 6, 22). Female tergite 9 bare (Fig. 8). Surstylus with 3 short, thick ventral bristles (Figs. 4, 20) . . 2

2. Antenna black, legs mostly luteous. Part of frons and body bare and shining. Middle ventral surstylar bristle inserted close to posteroventral surstylar bristle (Figs. 1, 4) . . . . *Aptilotus nigrimera,* n. sp.
– Antenna and legs mostly luteous. Frons and body entirely pruinose, without shining areas. Middle ventral surstylar bristle mid way between anteroventral and posteroventral surstylar bristle (Figs. 17, 20) . . *Aptilotus zumbadoi,* n. sp.

DESCRIPTIONS OF COSTA RICAN *APTILOTUS*

Aptilotus nigrimera Marshall, NEW SPECIES

(Figs. 1–8)

Description.—Body length 2.5–3.0mm. Body shining black; fore tarsus pale brown, legs otherwise yellow; antenna black to dark brown. Middle part of frons mostly bare and shining, ocellar triangle setulose but flanked by bare areas, interfrontal area with only a few setulae medially. Interfrontal bristles in 2–3 thin, subequal pairs. Eye height 4.0× genal height. Dorsocentral bristles in two postsutural pairs, anterior pair only slightly longer than acrostichal setulae, prescutellar pair long; only 2–3 rows of acrostichal setulae between dorsocentral areas. Scutellum almost transverse, twice as wide as long. Mid tibia with a long anterodorsal bristle proximally, a long distal dorsal bristle, and short anterodorsal and posterodorsal distal bristles. Ventral surface of tibia with only an apical bristle in both sexes. Wing and halter completely absent.

Male abdomen.—Tergite 1+2 longer than other tergites, uniformly dark. Sternite 5 with anterior and posterior margins strongly curved, anterior margin with with shallow medial notch; posteromedial pale part of sternite extending back to anterior margin of sternite so that pigmented part of sternite is very short medially, pale posteromedial section with brown pigmentation medially, rounded and narrowly notched posteromedially; pale area flanked by clusters of bristles. Surstylus broad, with thin bristles on a posterolateral bulge or ridge and 3 thick ventral bristles; a flattened, broadly bifid anteroventral bristle, a short, thick posteroventral bristle and a long, thick ventral bristle inserted much closer to posteroventral than anteroventral bristle. Gonostylus almost parallel sided, thick, distal part tapered. Basiphallus short, quadrate. Distiphallus with dorsal (functionally ventral) sclerite with a broad basal part, a narrow intermediate section and a distally forked part; ventral sclerite with a broad base and broad distal loop; membranous part of distiphallus with long distal dorsal lobes covered with flattened setulae.

Female abdomen.—Tergite 8 black, long, with a shallow anterior notch. Tergite 9 pale, with a short, transverse, anterior part and a large posterior part narrowly fused with cerci, surface bare (the usual 2 bristles absent). Cerci pale, shorter than tergite 9. Sternite 8 long and narrow, posterior part slightly enlarged with 4 small bristles. Sternite 9 broad, setulose except lateral extremes. Two internal vaginal sclerites present in addition to large, thin-rimmed rings joined by a discontinuous transverse piece (spectacles-shaped sclerite of Roháček, 1983). Spermathecae spherical, sclerotised parts of ducts slightly longer than spermathecal body.

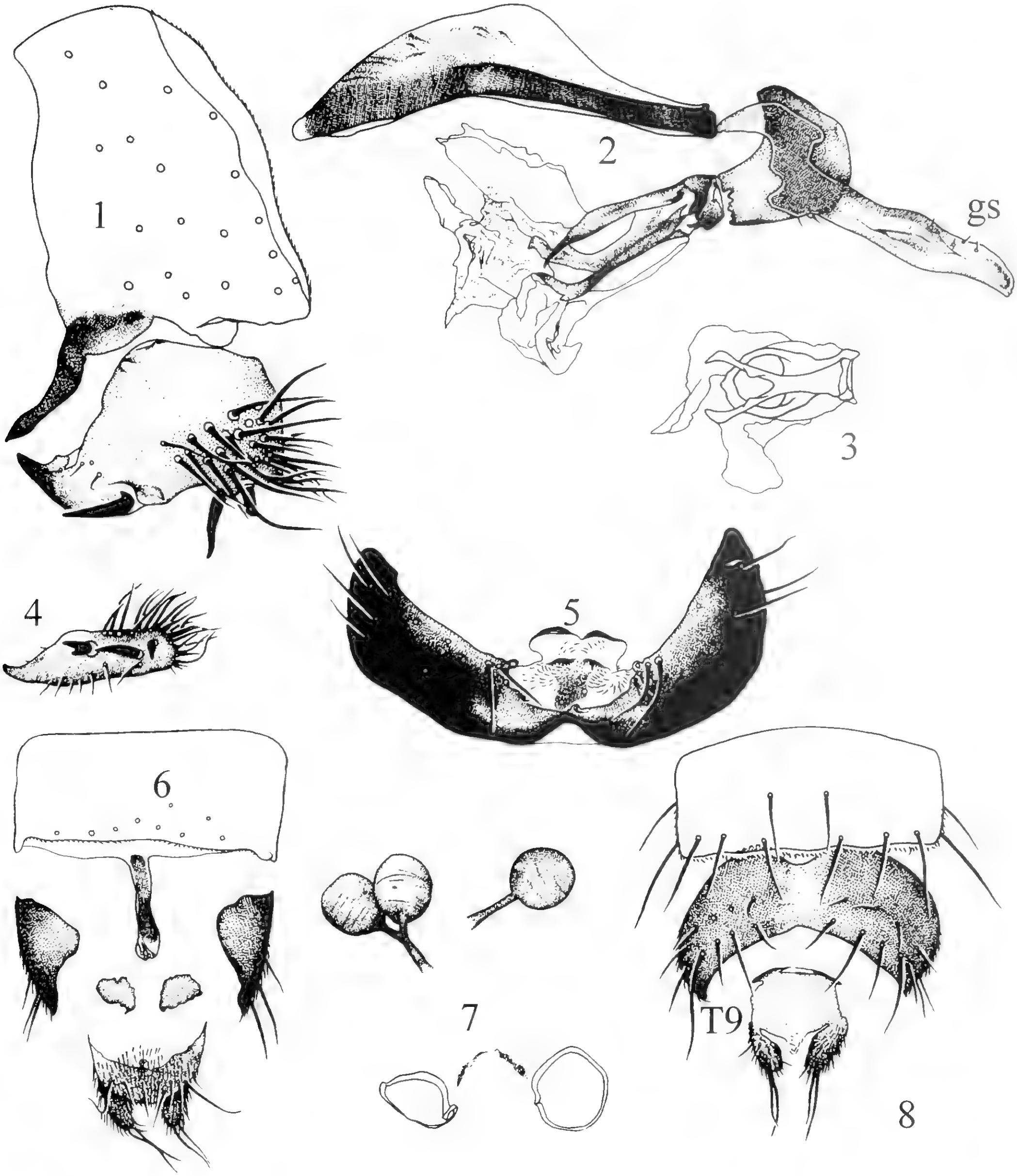
Types.—Holotype (♂,INBio) and 5 paratypes (3♂,2♀,GUE): COSTA RICA. Cartago Province, km. 89 Highway 2, Cerro de la Muerte, 10.ii.1995, aspirated among bamboo litter, S.A. Marshall. Paratype (♂,GUE) same as above, but sifted by R.S. Anderson.

Etymology.—The specific epithet refers to the dark antenna, a diagnostic character separating *A. nigrimera* from the closely related *A. zumbadoi.*

Aptilotus nigritibia Marshall, NEW SPECIES

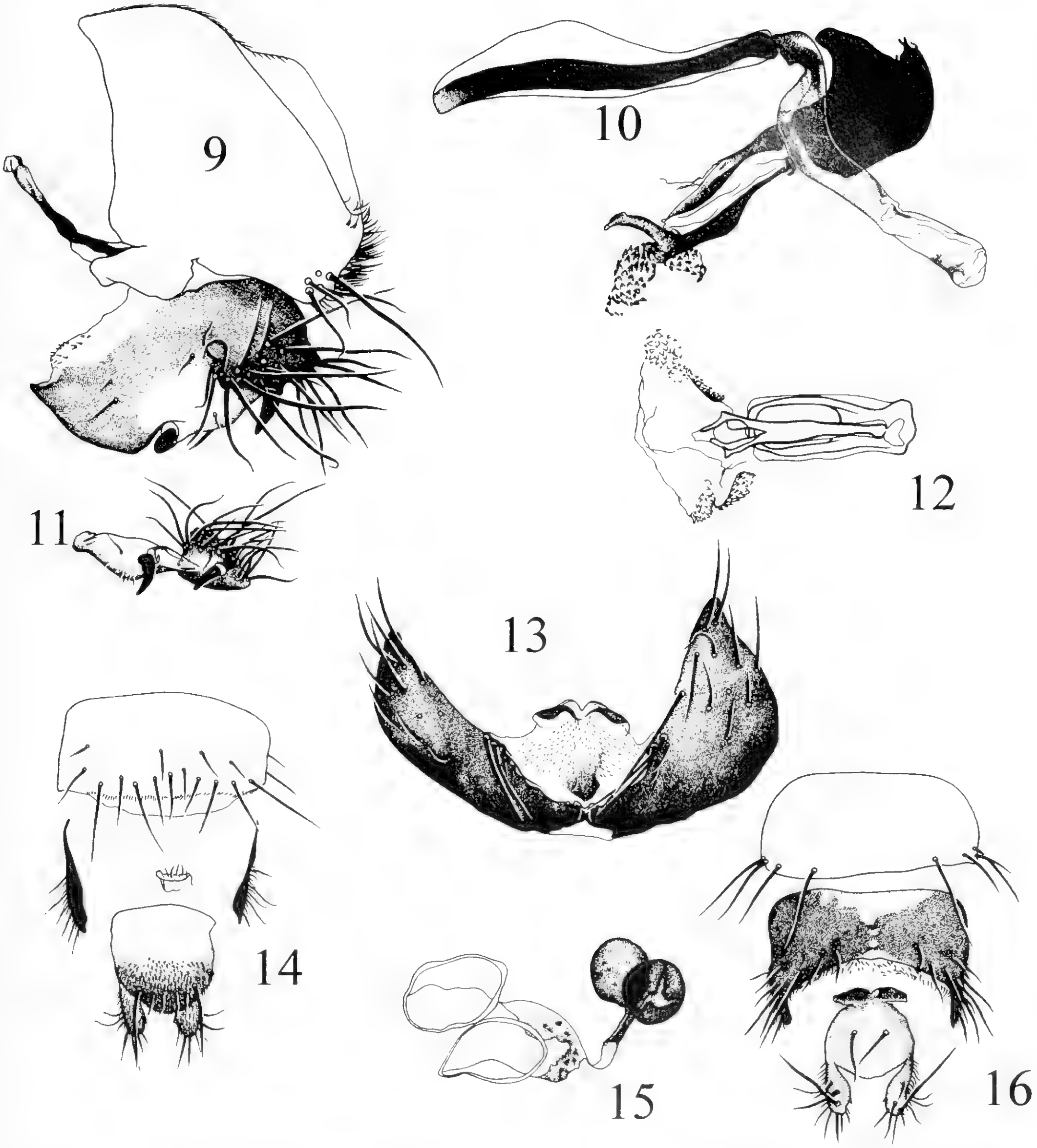
(Figs. 9–16)

Description.—Body length 2.0–2.5mm. Body almost entirely heavily pruinose, black; fore tibia and tarsi black, other tarsi brown, legs otherwise yellow; antenna yellow to pale brown. Head entirely pruinose, without shining areas. Interfrontal bristles



Figs. 1–8. *Aptilotus nigrimera.* 1, Male terminalia, left lateral. 2, Aedeagus and associated structures, left lateral. 3, Distiphallus, ventral view. 4, Surstylus, ventral view. 5, Sternite 5 of male. 6, Female terminalia, ventral. 7, Spermathecae and associated sclerites. 8, Female terminalia, dorsal. Abbreviations: gs = gonostylus (paramere of earlier papers); T9 = tergite 9 (epiproct of earlier papers).

in 2–3 thin, subequal pairs. Eye height 4.5× genal height. Dorsocentral bristles in two postsutural pairs, anterior pair twice as long as acrostichal setulae, prescutellar pair much longer; 4 rows of acrostichal setulae between dorsocentral areas. Scutellum almost transverse, twice as wide as long. Mid tibia with a long anterodorsal bristle prox-



Figs. 9–16. *Aptilotus nigritibia.* 9, Male terminalia, left lateral. 10, Aedeagus and associated structures, left lateral. 11, Distiphallus, ventral view. 12, Surstylus, ventral view. 13, Sternite 5 of male. 14, Female terminalia, ventral. 15, Spermathecae and associated sclerites. 16, Female terminalia, dorsal.

imally, a long distal dorsal bristle, a short anterodorsal distal bristle and a smaller posterodorsal distal bristle. Ventral surface of tibia with only an apical bristle in both sexes. Wing and halter completely absent.

Male abdomen.—Tergite 1+2 longer than other tergites, uniformly dark. Sternite 5 with anterior and posterior margins strongly curved, anterior margin with shallow anteromedial notch; posteromedial pale part of sternite extending back to anterior margin of sternite so that pigmented part of sternite is very short medially; pale posteromedial section with brown pigmentation medially, rounded and narrowly notched posteromedially; pale area flanked by clusters of bristles. Surstylus broad, with thin bristles on a posterolateral bulge or ridge and 2 thick ventral bristles; a flattened anteroventral bristle and a short, thick posteroventral bristle; a very small ventral bristle inserted close to posteroventral bristle. Gonostylus of medium width and weakly S-shaped, distal part expanded. Basiphallus short, quadrate. Distiphallus with dorsal (functionally ventral) sclerite with a broad basal part, a narrow intermediate section and a distal loop which is not closed distally; ventral sclerite with a broad base and broad distal loop; membranous part of distiphallus with long distal dorsal lobes covered with conspicuous flattened setulae.

Female abdomen.—Tergite 8 black, long, with a shallow anterior notch. Tergite 9 pale, with a short, transverse, anterior part and a large posterior part narrowly fused with cerci and with 2 dorsal bristles. Cerci pale, shorter than tergite 9. Sternite 8 small, transverse, with 4 small bristles. Sternite 9 broad, setulose except lateral extremes. Indistinct vaginal sclerites present in addition to large, thin-rimmed rings joined by a discontinuous transverse piece (spectacles-shaped sclerite of Roháček 1983). Spermathecae spherical, sclerotised parts of ducts slightly longer than spermathecal body.

Types.—Holotype (♂,INBio) and 2 paratypes (1♂,1♀,GUE): COSTA RICA: Cartago Province, km. 89, Highway 2, Cerro de la Muerte, 10.ii.1995, aspirated among bamboo litter, S.A. Marshall.

Etymology.—The specific epithet refers to the black tibia which differentiates *A. nigritibia* from Costa Rican congeners.

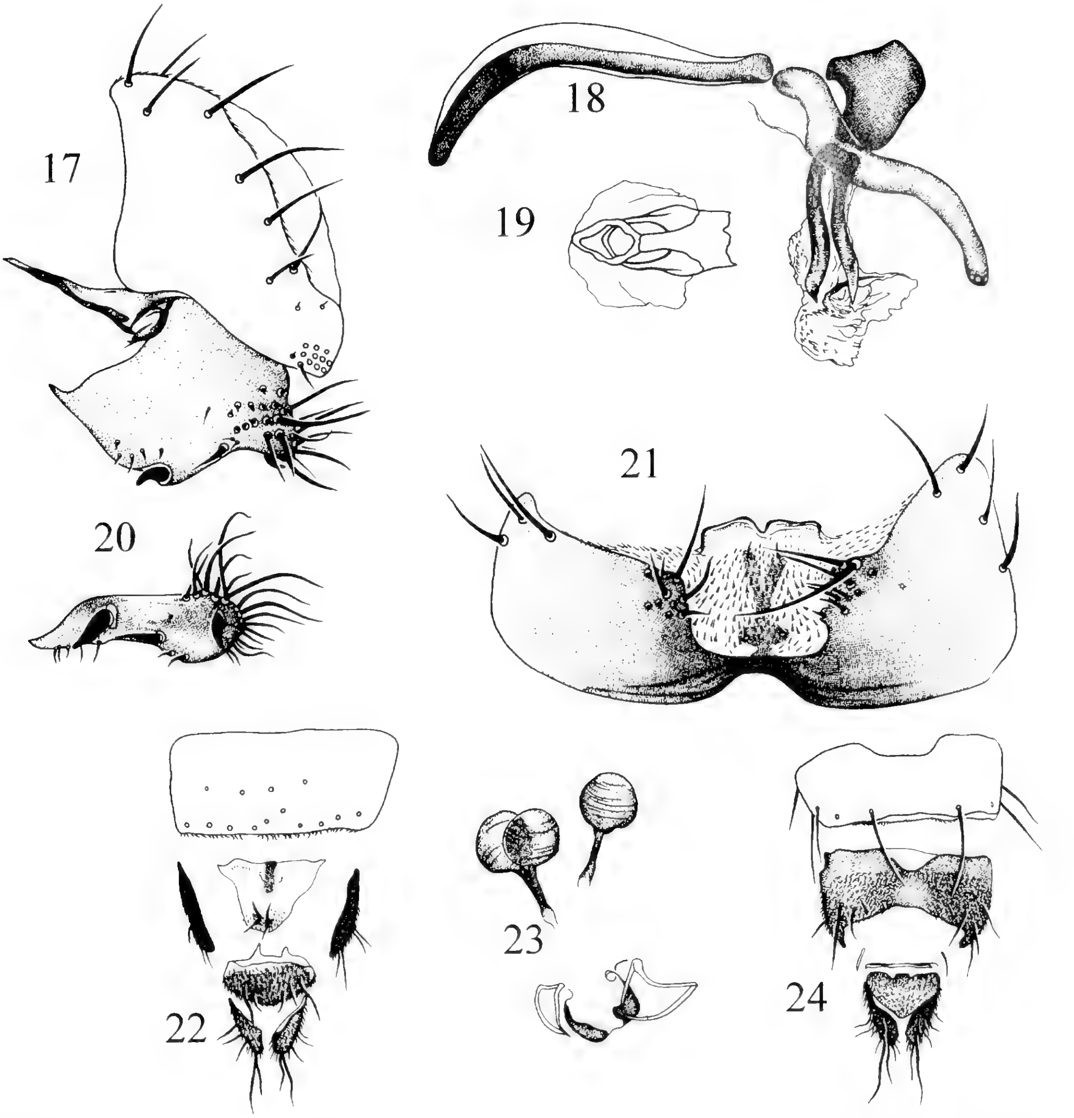
Aptilotus zumbadoi Marshall, NEW SPECIES

(Figs. 17–24)

Description.—Body length 2.0–2.5mm. Body almost entirely heavily pruinose, black; fore tibia and tarsi black, other tarsi brown, legs otherwise yellow; antenna yellow to pale brown. Head entirely pruinose, without shining areas. Interfrontal bristles in 2–3 thin, subequal pairs. Eye height 4.5× genal height. Dorsocentral bristles in two postsutural pairs, anterior pair twice as long as acrostichal setulae, prescutellar pair much longer; 4 rows of acrostichal setulae between dorsocentral areas. Scutellum almost transverse, twice as wide as long. Mid tibia with a long anterodorsal bristle proximally, a long distal dorsal bristle, a short anterodorsal distal bristle and a smaller posterodorsal distal bristle. Ventral surface of tibia with only an apical bristle in both sexes. Wing and halter completely absent.

Male abdomen.—Tergite 1+2 longer than other tergites, uniformly dark. Sternite 5 of uniform length, neither anterior nor posterior marging strongly curved, anterior margin with broad medial notch; posteromedial pale part of sternite extending back almost to anterior margin of sternite, with elongate brown pigmentation medially, quadrate and narrowly notched posteromedially; pale area flanked by clusters of bristles. Surstylus broad, with thin bristles on a posterolateral bulge or ridge, and 3 thick ventral bristles; a flattened anteroventral bristle, a short, thick posteroventral bristle and a ventral bristle midway between the other two. Gonostylus thin, of uniform width and weakly S-shaped. Basiphallus short, quadrate. Distiphallus with dorsal (functionally ventral) sclerite with a broad basal part, a narrow intermediate section and a distal loop; ventral sclerite with a broad base and broad distal loop.

Female abdomen.—Tergite 8 long, bare and shining medially and anteriorly, with a shallow anterior notch. Tergite 9 pale, with a short, transverse, anterior part and a large posterior part narrowly fused with cerci, surface bare (the usual 2 bristles absent). Cerci slightly longer than tergite 9. Sternite 8 long and narrow, posterior part separate from long and narrow part, with 4 small bristles. Sternite 9 broad, setulose except lateral extremes. Indistinct internal vaginal sclerotisation present in addition to large, thin-rimmed rings joined by a broad sclerite (spectacles-shaped sclerite of Roháček



Figs.17–24. *Aptilotus zumbadoi.* 17, Male terminalia, left lateral. 18, Aedeagus and associated structures, left lateral. 19, Distiphallus, ventral view. 20, Surstylus, ventral view. 21, Sternite 5 of male. 22, Female terminalia, ventral. 23, Spermathecae and associated sclerites. 24, Female terminalia, dorsal.

1983). Spermathecae spherical, sclerotised parts of ducts slightly longer than spermathecal body.

Types.—Holotype (♂, INBio) and 3 paratypes (2♂,1♀,GUE): COSTA RICA: Cartago Province, km. 89, Highway 2, Cerro de la Muerte, 10.ii.1995, aspirated among bamboo litter, S.A. Marshall.

Paratypes.—COSTA RICA. Cartago Province, 2kmS Villa Mills, 3000m, 10.ii.1996, ridge top mature oak forest litter, R.S. Anderson (1♂,2♀,GUE); San Jose Province, km. 68 Highway 2, Tres de Junio Bog, 2600m, 10.ii.1996, litter from forest adjacent to Sphagnum bog, R.S. Anderson (2♂,GUE); Cerro de la Muerte, 7–13.iv.1985, pan traps, oak cloud forest, L. Masner and H. Goulet (1♂,GUE); km. 95, Highway 2, 3200m, 13.iv.1985, oak cloud forest, L. Masner (1♂, GUE).

Etymology.—The specific epithet is a patronym in recognition of INBio's Diptera specialist, Manuel Zumbado. Without Manuel's help we could not have made collections at the type localities for this and other species described here.

ACKNOWLEDGMENTS

Dr. Robert Anderson, Canadian Museum of Nature, provided specimens, advice concerning high altitude insects of Central America, and company in the field. Manuel Zumbado, Instituto Nacional de Biodiversidad (INBio), Costa Rica, provided invaluable advice and field support. Rebecca Langstaff did the illustrations. Paratypes are retained in the University of Guelph Insect Collection (GUE).

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COMPARISON OF FIXATION AND DRYING PROCEDURES FOR SCANNING ELECTRON MICROSCOPY AMONG INSECT BODY TYPES

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Abstract.—Four different procedures used to prepare insect specimens for scanning electron microscopy were compared using three insect body types that represent unique obstacles to obtaining good quality micrographs, i.e., clean and life-like in appearance. The micrographs produced using each procedure were rated for cleanliness, structural integrity, and imaging quality. Each procedure involved: fixation, post-fixation, and drying. Procedure 1 involved fixation by freezing @ −10°C and drying by critical-point drying. Procedure 2 involved fixation by submersion in 70% ethanol and drying by critical-point drying. Procedure 3 involved fixation by submersion in 70% ethanol and drying with hexamethyldisilizane. Procedure 4 involved fixation by submersion in a hot water bath at 80°C and drying with hexamethyldisilizane. Procedure 2 gave the best overall results, but procedures 3 and 4 were best on insects with small lightly sclerotized bodies and unsclerotized larvae, respectively. Difficulties associated with histological study of insects are discussed.

Key Words: Scanning electron microscopy, freezing fixation, ethanol fixation, hot water fixation, procedures

Scanning electron microscopy (SEM) is used for a variety of purposes in Entomology. The most common applications involve taxonomic and morphological studies. While SEM is often an indispensable tool in these types of studies, the quality of the images can vary considerably; much of this variation is related to problems specific to insects. Quality images useful for scientific study require that the specimens be clean and life-like in appearance (i.e. little or no shrinkage).

The procedures for preparation of insect specimens for SEM are fairly standard, although variations during fixation and dehydration are common (see below). Papers that include SEM micrographs may not describe their procedures or simply acknowledge an individual or department for their help in the production of SEM micrographs, thus, information on new or different successful techniques are difficult to obtain. Insects present a wide range of histological variables, and no one treatment is universally applicable to every taxa or stage. The objective of this study was to compare different procedures used on different insect body types to determine which, if any, provided consistent and predictable results, or which procedure was best suited with selected taxa to obtain clean, life-like specimens.

For the purposes of this paper, we assume the reader has basic knowledge of SEM preparation methods; however, the following terms are defined:

Accelerating voltage.—Accelerating voltages are typically set at ca. 10–20kV for biological tissues. The resultant resolution of surface detail usually does not exceed 10,000 diameters of magnification.

Fixation.—The cessation of life in such a manner as to retain the structural and biochemical integrity of the specimen and its tissues. See Sabatini et al. (1963), Humanson (1967), Barbosa (1974), and Dawes (1988) for basic principles of fixation. This is the most important step in histological preparation.

Postfixation.—There are many postfixation processes for biological tissues depending on the examination method. Metallic impregnation with heavy metal salts is commonly used for SEM (Sabatini, et al. 1963, Dawes 1988). The most common metallic salt is osmium tetroxide (OsO_4) which acts to bind lipids, thus increasing the electron density of the tissues. Electron density in biological tissues allows for higher accelerating voltages without charging, with the subsequent gain in resolution. Enhanced contrast of the specimen also can result from metal impregnation leading to a better quality image for study (Dawes 1988). OsO_4 is labeled as a poison. A Material Safety Data Sheet is provided with the purchase of OsO_4; precautions on proper handling and disposal should be followed.

Drying (Dehydration).—Tissues must be completely dry, including absence of metabolic water, before sputter-coating and examination with SEM. There are several drying procedures. The most common is the use of a critical-point dryer with liquid CO_2 as the transition fluid (Dawes 1988, Gordh and Hall 1979). Hexamethyldisilizane (HMDS) is another chemical which dries tissues (Adams et al. 1987, Nation 1983) and is employed in some of the procedures listed below. HMDS is labeled as corrosive and highly toxic. Again, a Material Safety Data sheet is provided with purchase and procedures for proper handling should be followed.

Body types.—Three distinct body types, difficult to successfully prepare for SEM, were selected for analysis A) small bodies (<2 mm long), B) bodies that produce wax and C) soft-bodied forms, which include both immature stages or insect imagos and immatures with little sclerotization of the integument. These types are referred to as 'small', 'waxy' or 'soft' body types. We used *Encarsia* sp. (Hymenoptera: Aphelinidae) a parasitoid that is ca. 1.0 mm long, to represent the small body type. For waxy body types, we used the nymphs of two species of whitefly, *Bemisia argentifolii* Bellows and Perring and *Dialeurodes citri* (Ashmead) (Homoptera: Aleyrodidae). The nymphs of these two whitefly species also are soft-bodied. We used late-instar larvae of *Musca domestica* L. (Diptera: Muscidae) to represent the soft body type.

SPECIMEN PREPARATION

The problems associated with insects and their preparation for SEM involve primarily the cuticle, and secondarily, the presence of waxes and lipids. All insects possess a multi-layered cuticle which presents a unique obstacle to histology and, depending on the taxa involved, may be heavily sclerotized or rather thin and flexible (Humason 1967, Barbosa 1974).

The cuticle provides a barrier to the materials used in each step in specimen preparation: fixation, postfixation and drying (Barbosa 1974, Dawes 1988). During fixation, the cuticle can prevent adequate penetration of the fixative into the body, and thorough fixation of tissues. Poor fixation may also cause problems later during postfixation as tissues that have not been fixed will not accept the post-fixative, and may be more susceptable to electron absorption which results in charging (Dawes 1988). Drying of the tissues may also be hampered by partial fixation, allowing water and alcohol to remain in the specimen. Such tissues may burst when placed in a vacuum during sputter-coating and SEM examination. Metamorphosis also poses special problems during processing of tissues for SEM, for if the specimen being processed is in a period of structural rearrangement, the cuticle may be prone to shrinkage and severe charging problems.

Other problems associated with SEM examination of insects involve the presence of waxes and lipids. All biological tissues contain lipids, which tend to absorb electrons, and thus lead to charging. Many insects also produce waxes which also do not fix well, absorb electrons, and may obscure certain structures. The post-fixative, osmium tetroxide, is typically used to bind lipids to make them more electron dense, thus eliminating electron absorption and consequent charging (Dawes 1988).

SEM facilitates examination of the surface features of very tiny structures. Many insects are quite small or bear minute structures on their bodies. Although easily penetrated by preparation materials, these small-bodied insects pose difficulties during examination as they tend to become electrically charged.

With these problems in mind, we applied four procedures to specimens of taxa which represent the three body types described above. Comparisons of the procedures are presented with a rating scale for each.

MATERIALS AND METHODS

Each procedure involved three basic steps: 1) fixation, 2) post-fixation, and 3) drying. Three methods of fixation were employed in the current study: 1) freezing @ −10°C, 2) submersion in ethanol (50–70%), and 3) a hot water bath at 80°C. A 2% aqueous solution of osmium tetroxide was always used as the postfixative. Metallic impregnation as a postfixative may not be commonly used for some insect taxa, but has been shown to be beneficial and thus is included in each procedure (Dawes 1988, Headrick, unpublished data). Dehydration involved placing the specimens in a series of ethanol baths at dilutions of 15, 30, 50, 70, 80, 90, 95 and finally 100%, followed either by critical-point drying using liquid CO_2 as a transition fluid, or HMDS. Following the 100% ethanol bath in two procedures the specimens were placed in HMDS under a fumehood. After 20 min. the remaining HMDS was siphoned away with a pipette, thus removing any accumulated particles or residues. A second bath of clean HMDS was added and the specimens were dried to completion by evaporation of the HMDS in a fumehood (ca. 30 min).

Procedure 1.—This method used freezing @ −10°C for fixation. The specimens were postfixed by immersion in the solution of osmium tetroxide for 24 h. They were next rinsed twice with deionized water, then dehydrated through a series of increasing ethanol dilutions. Specimens remained in each dilution for 20 min and ended in 100% ethanol. Drying used critical-point drying. This procedure was applied to 10 specimens each of *Dialeurodes citri, Bemisia argentifolii,* and *Encarsia* sp.

Procedure 2.—Specimens were fixed in 50% ethanol for 24 h, then rehydrated to distilled water through a decreasing series of ethanol dilutions for post-fixation in osmium tetroxide. Postfixation, dehydration, and drying were identical to procedure 1. Procedure 2 was applied to 10 specimens each of *D. citri, B. argentifolii,* and *E.* sp.

Procedure 3.—Fixation was in 70% ethanol, and postfixation in 2% osmium tetroxide for 24 h. The specimens were then dehydrated through a series of increasing ethanol dilutions up to 100% for 15 min in each dilution. The specimens were dried using two, 30-min baths of HMDS. This procedure was applied to 10 specimens of *E.* sp.

Procedure 4.—Specimens were fixed in a bath of 80°C tap water and subjected to ultrasonic cleaning for 10 min to remove residue from the body (Belcari 1987). After 5 min of fixation, the specimens were cut in half to facilitate the fixation process. The specimens were then post-fixed in osmium tetroxide for 24 h, and rinsed twice with deionized water. The specimens next were dehydrated in an increasing series of ethanol dilutions, up to 100%; each ethanol bath lasted 20 min. Two 30 min baths in HMDS finally were used to dry the specimens. This procedure was applied to 12 specimens of *M. domestica.*

All dried specimens were mounted on

aluminum stubs with double-sided cellophane tape and sputter-coated with a gold-palladium alloy using a Hummer V. Specimens were examined on a JEOL JSM C35 scanning electron microscope in the Department of Nematology at the University of California, Riverside. Scanning electron micrographs were prepared at 15 kV accelerating voltage on Polaroid 55P/N film.

To quantify the results of our comparative survey, we used the following rating system. We judged SEM micrograph quality on three variables: cleanliness, structural integrity, and imaging. Each of these categories had two subdivisions. We rated cleanliness at two levels, "particle" and "obscuring." Particle is macroscopic accumulation of atmospheric or environmental debris by the specimen. Particle accumulation can take place during any phase of the processes used for specimen preparation. Obscuring is a microscopic phenomenon in which materials such as waxes, resins or other natural products are chemically affected by the SEM preparation processes and adhere to the surface of the specimen, thus obscuring minute surface details. Similar obscuring problems arise from metallic filming or sputter-coating processes (Dawes 1988). The rating system ranged from 0–3 in both categories. For particle cleanliness, a 0 indicated that the specimen was covered with particles, and thus rendered useless for study (Fig. 1A); while 3 meant the specimen was free of any obscuring particles. With respect to obscuring residues, a 0 meant minute structures were obscured from view, and a 3 indicated that all structures could be seen clearly.

Structural integrity includes both macroscopic and microscopic levels. Macroscopic structural integrity encompasses the body as a whole. Microscopic structural integrity relates to minute structures on the body, such as setae or sensoria. We rated both of these categories as good, fair or poor. Good structural integrity evidenced little to no structural collapse. Fair structural integrity may have some collapse, but not loss of useable micrographs for study. Poor structural integrity resulted from collapse of the specimen, or loss of small structural details, preventing observation of important features (Fig. 1B, C).

Imaging includes resolution and charging. Resolution at magnifications greater than 2000× was rated as 0–3. A 0 indicated that the image could not be adequately resolved and a 3 indicated that resolution above 10,000× was obtainable. Charging in specimens is either present (+) or absent (−) (Fig. 1D).

Our rating system is summarized as follows and was used to build Tables 1–3:

A. Specimen cleanliness:
  1. Particle—0–3
  2. Obscuring—0–3
B. Structural Integrity:
  1. Macroscopic—Good, fair, or poor
  2. Microscopic—Good, fair, or poor
C. Imaging:
  1. Resolution at higher magnifications (>2000): 0–3
  2. Charging: present (+) or absent (−).

RESULTS

Procedure 1.—Freezing fixation

Dialeurodes citri.—With this procedure specimens were generally clean and no structures were obscured from view (Fig. 2A). At higher magnification, resolution was rated as 1 (Fig. 2B). Collapse of the body and its smaller structures was not observed and charging did not occur with these specimens.

Bemisia argentifolii.—Cleanliness with respect to particles was good (Fig. 2C), but most minute structures were obscured by waxes. Because the specimens were not clean, the tracheal furrows were left full of wax (Fig. 2D); this was more life-like, but obscured potentially important taxonomic characters. Severe charging was present in some specimens. Resolution at higher magnification was rated as 1.

Encarsia sp.—The specimens bore obscuring residues (Fig. 2E). Macroscopic and

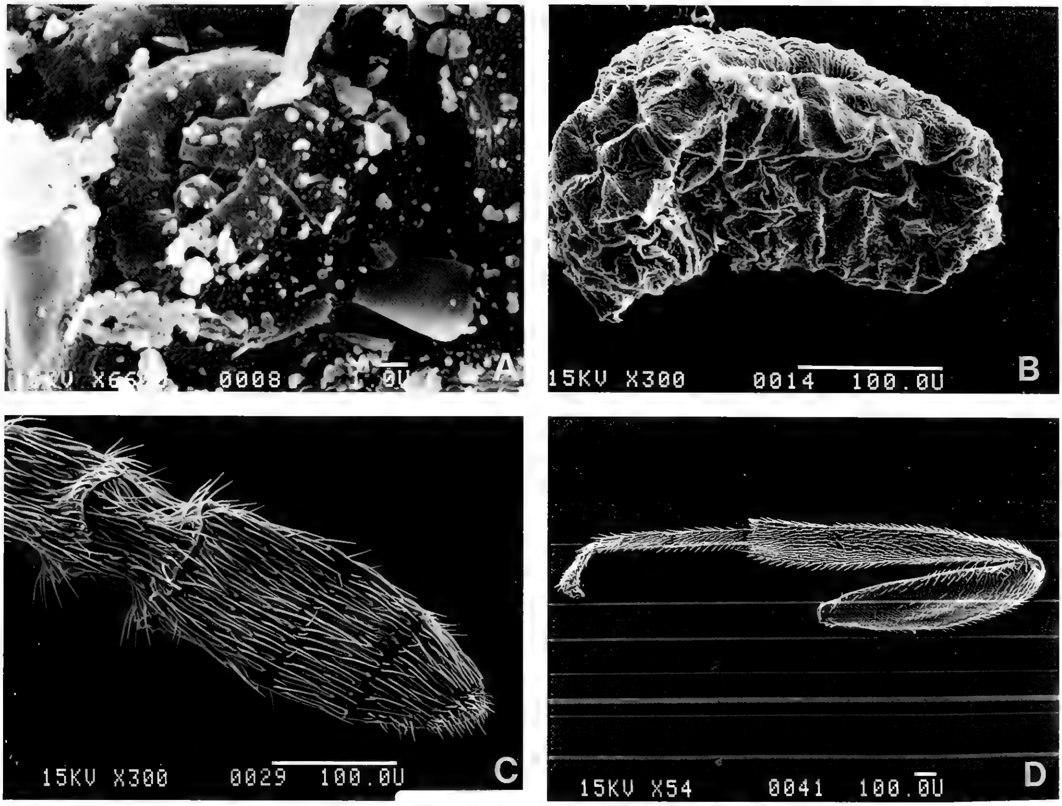

Fig. 1. Examples of poor SEM micrographs. A, Surface details obscured by particulate matter, this should look like Figure 5C. B, Shinkage of soft-bodied dipteran larva. The shrinkage on this specimen was so severe that even the most minute of structures was collapsed. C, Shinkage of a hymenopteran parasitoid antenna. D, An example of what charging does to a micrograph.

Table 1. Rating results for Procedure 1, freezing fixation.

Rating	Taxa		
	D. citri	*B. argentifolii*	*E.* sp.
Cleanliness			
Particle	2	2	2
Obscuring	2	1	1
Structural integrity			
Macro	good	good	poor
Micro	good	fair	poor
Imaging			
Resolution	1	1	0
Charging	(−)	(+)	(−)

Table 2. Rating results for Procedure 2, ethanol fixation.

Rating	Taxa		
	D. citri	*B. argentifolii*	*E.* sp.
Cleanliness			
Particle	2	2	2
Obscuring	2	2	2
Structural integrity			
Macro	good	good	good
Micro	good	good	good
Imaging			
Resolution	2	2	1
Charging	(−)	(−)	(−)

Table 3. Rating results for Procedures 3, ethanol fixation and HMDS, and Procedure 4, water bath fixation and HMDS.

	Procedure 3	Procedure 4
Rating	*E.* sp.	*M. domestica*
Cleanliness		
Particle	2	3
Obscuring	3	3
Structural integrity		
Macro	fair	good
Micro	good	good
Imaging		
Resolution	3	3
Charging	(−)	(−)

microscopic structures showed considerable collapse (Fig. 2F). No charging occurred, but resolution at higher magnifications was rated as 0.

Procedure 2.—Ethanol fixation

Dialeurodes citri.—The specimens were free of particles and obscuring residues (Fig. 3A). Resolution at higher magnification was rated as 2 (Fig. 3B). Collapse and charging were not problems.

Bemisia argentifolii.—The specimens (Fig. 3C), and specifically, the tracheal furrows were free of waxes (Fig. 3D). Resolution was rated as 2 at higher magnification. There was no structural collapse or charging.

Encarsia sp.—The specimens were clean with little collapse (Fig. 3E). At higher magnifications, the resolution obtained was rated as 1 (Fig. 3F).

Procedure 3.—Ethanol fixation, HMDS

Encarsia sp.—The specimens were mostly free of particles or obscuring residues (Fig. 4A). Microscopic collapse of structures was not a problem with this procedure (Fig. 4B, C); although there was some macroscopic collapse in the area of the propodeum (Fig. 4A). Resolution was extremely good up to 18,000× (Fig. 4C), and there was no charging.

Procedure 4.—Hot water fixation/ sonication, HMDS

Musca domestica.—The specimens were very clean with minimal obscuring residues (Fig. 5A, B, C). No collapse was evidenced and the smallest structures remained lifelike in appearance (Fig. 5C). Resolution was excellent and there was no charging.

DISCUSSION

Casual examination of entomological journals reveals a considerable range in the quality of SEM micrographs. Technological advances in SEM's have made them easier to use and have provided the user with more options for producing good quality micrographs. Adjusting the physical parameters of the SEM, such as, accelerating voltage, stigmator, focus, and spot size can now be done with the touch of a button; adjusting features of the image like contrast and brightness is also made simpler. Most of the newer SEM's have the ability to digitize images and save them as files for importation into image-enhancing software. Once stored as a digitized image the user can then opt for "cleaning-up" or enhancing image quality after the fact.

Although technology is moving ahead on the hardware end, the fact remains that preparation of the specimen is still the most important first step and this is the area where little comparative work on procedures has been conducted. Some new techniques reported in the literature involve lengthy processing, the use of chemicals or materials that are difficult to handle, or specialized equipment not commonly available (Grodowitz et al. 1982; Colwell and Kokko 1985). While these expenditures of time and resources may be useful for intensive study of a paticular taxon, the applicability of these methods to other insect taxa or to specimens of different body types is limited.

Our comparative analysis of methods commonly used for SEM preparation among different types of insects is a first

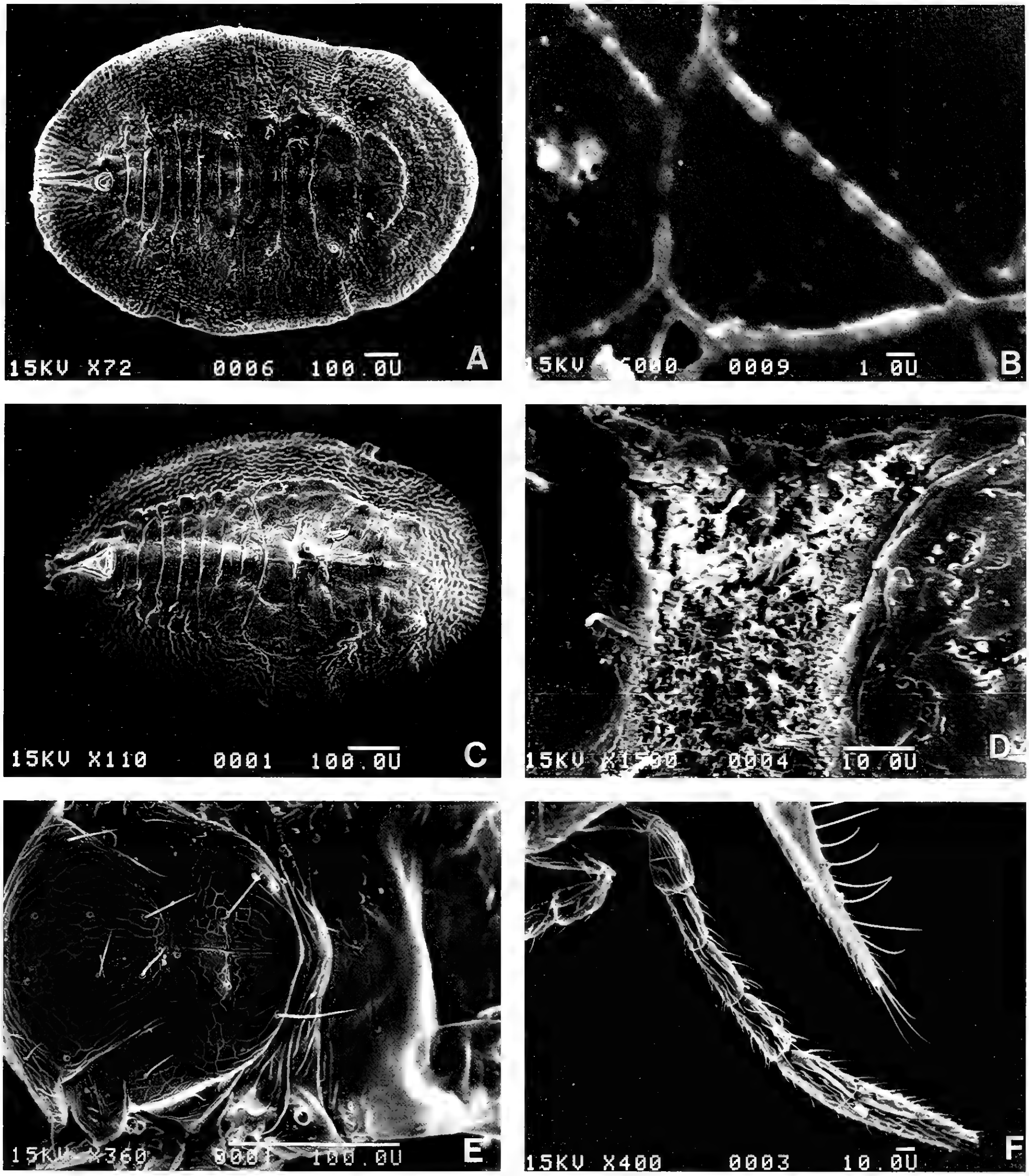

Fig. 2. Freezing fixation. A, *Dialeurodes citri* fourth instar nymph, dorsal view. B, *D. citri*, detail of dorsal integumental reticulation. C, *Bemisia argentifolii* fourth instar nymph, dorsal view. D, *B. argentifolii*, detail of the ventral marginal opening of the tracheal furrow. E, *Encarsia* sp., female, dorsal view of the thoracic region. F, *E.* sp., female, antenna.

step in determining the applicability of these methods in obtaining consistent, quality specimens.

The procedure which ranked the highest among all four taxa tested was ethanol fixation, followed by osmium tetroxide postfixation, dehydration in ethanol, and critical-point drying. This procedure provided generally clean specimens with little collapse or charging. Its limitation may be the loss of secreted surface features, such as wax, thus, rendering the specimen "unlife-

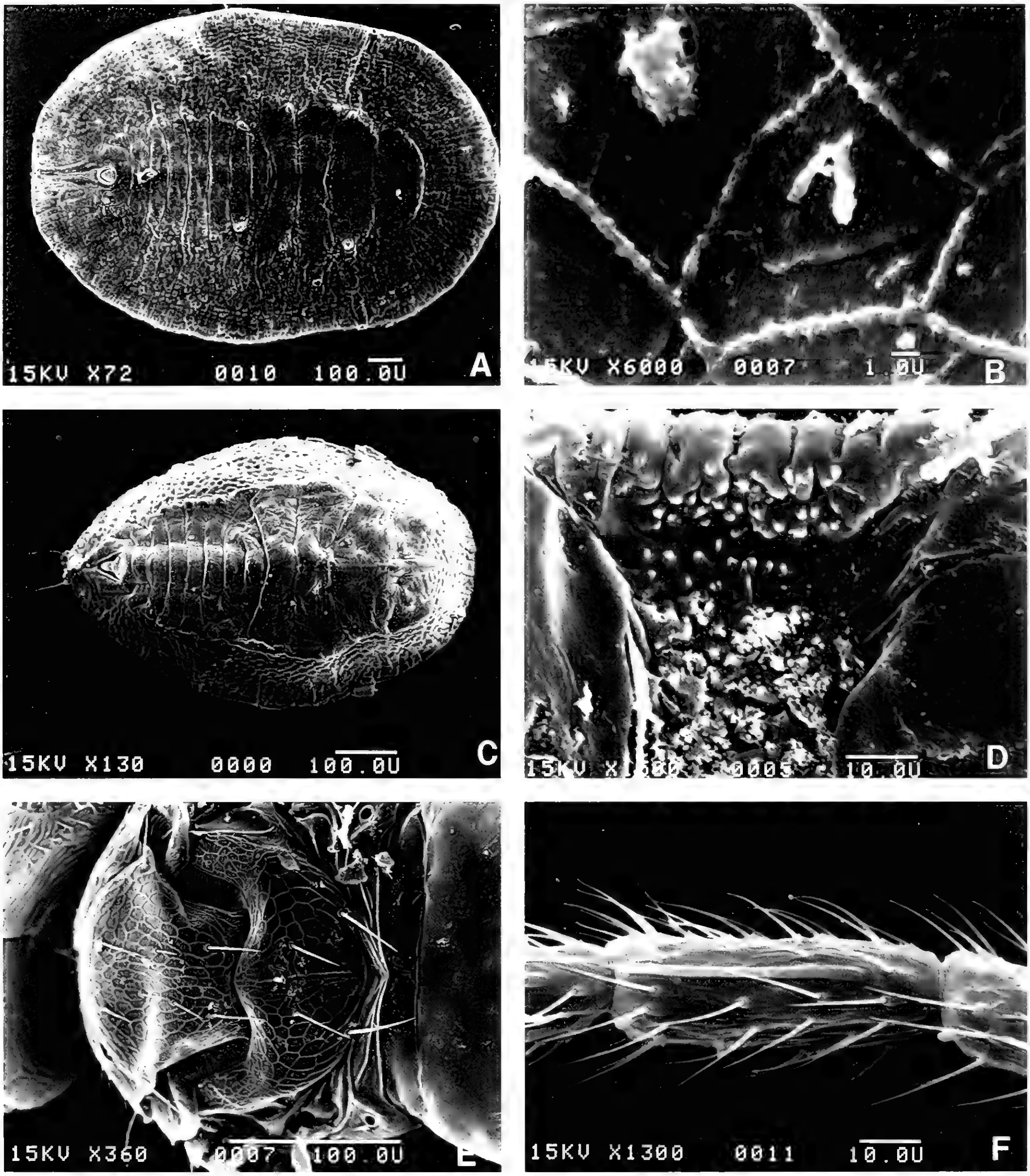

Fig. 3. Ethanol fixation. A, *Dialeurodes citri* fourth instar nymph, dorsal view. B, *D. citri,* detail of dorsal integumental reticulation. C, *Bemisia argentifolii* fourth instar nymph, dorsal view. D, *B. argentifolii,* detail of the ventral marginal opening of the tracheal furrow. E, *Encarsia* sp., female, dorsal view of the thoracic region. F, *E.* sp., female, detail of a funicle segment of the antenna.

like", but again, better suited to viewing integumental surface features. This method has also been used successfully to examine a wide array of insect taxa and insect stages (DHH, unpublished data). Ethanol fixation has produced the best and most consistent results for SEM examination of insect eggs (DHH, unpublished data). In the present study, fixation by freezing also gave good results and eliminated the need for the extra rehydration steps before postfixing, as is needed with ethanol fixation. Procedures 3

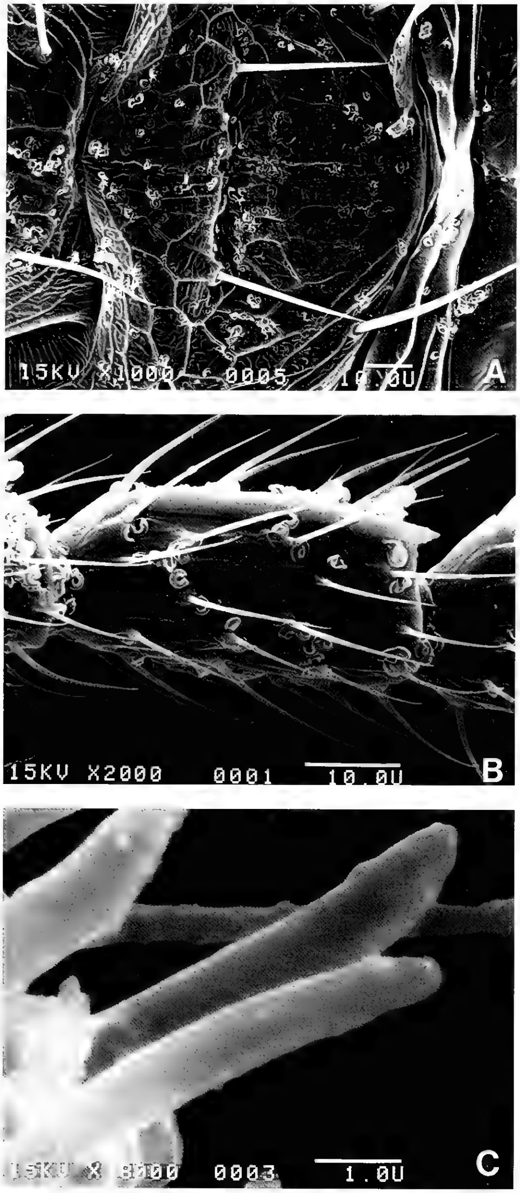

Fig. 4. Ethanol fixation, HMDS, *Encarsia* sp., A, Female, dorsal view of the thoracic region. B, Female, detail of a funicle segment of the antenna. C, The apex of the antennal club.

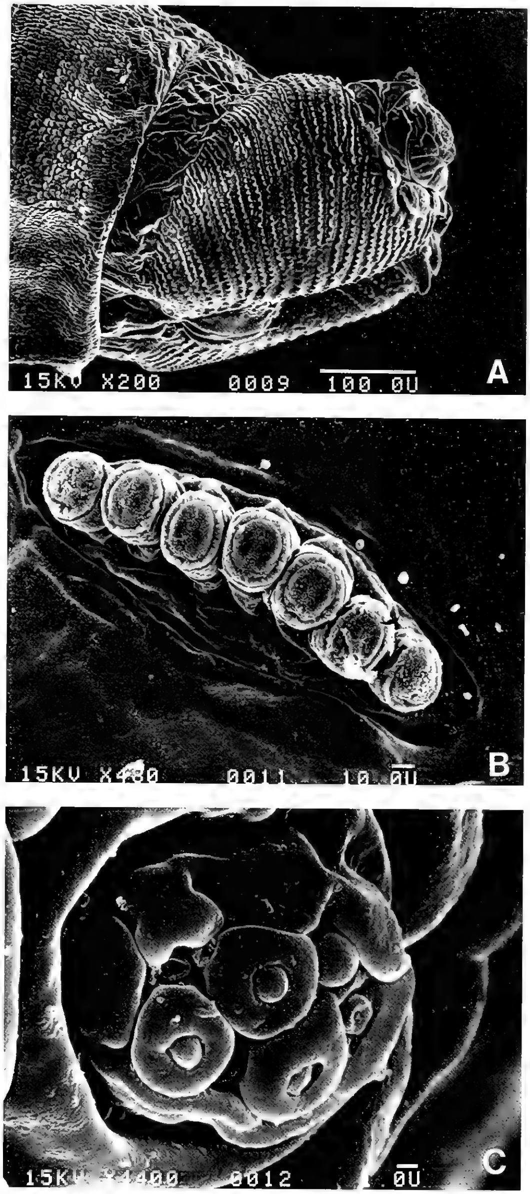

Fig. 5. Hot-water fixation, HMDS, *Musca domestica*. A, Gnathocephalon, right lateral view. B, Anterior prothoracic spiracles. C, Terminal sensory organ of the anterior sensory lobe.

and 4 gave excellent results, but were not widely applicable. Dipteran larvae are unusally prone to shrinkage and distortion during processing for SEM. Further, they are often contaminated with debris and other by-products of their various micro-habitats that are not easily removed by chemical means, e.g., baths in hexanes, bleach, etc. Other taxa such as lepidopteran or coleopteran larvae can withstand such harsh treatments without damage. We have found that procedure 4 works exceptionally well to provide clean, undistorted larvae; larger-bodied forms are cut apart to facillitate penetration during the fixation process.

The procedure that may be considered the best will vary with the ultimate goal of the user. For example, life-like appearance may not be compatible with ethanol fixation. More taxa and body types must be studied in a comparative fashion. The inclusion of preparation methods in the literature, however briefly, would aid development of procedures that predictably provide clean, life-like specimens and good quality SEM images.

ACKNOWLEDGMENTS

We thank Carol Meisenbacher and Bobbie Orr for technical assistance and the use of specimens from their colonies. We also thank R. D. Goeden and J. M. Heraty for reviews of early drafts of this manuscript.

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DESCRIPTIONS OF A NEW GENUS AND SIX NEW SPECIES OF NEARCTIC LESTREMIINAE (DIPTERA: CECIDOMYIIDAE)

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Abstract.—A new genus and six new species of Nearctic gall midges are described as new to science. These are: ***Amedia floridana,*** the only lestremiine totally lacking the medial vein; ***Allarete bicornuta, Neurolyga longipes*** and ***Neurolyga pritchardi,*** all three characterized by their remarkable male genitalia; ***Heterogenella californica,*** the first record of this genus in North America and the first species within the tribe Bryomyiini showing brachypterous females; and ***Polyardis occulta,*** representing a further case of brachyptery in the female within the genus.

Key Words: Diptera, Cecidomyiidae, Lestremiinae, Nearctic Region, new genus, new species

The lestremiine gall midges in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., contain a large number of unidentified or only generically determined specimens, mostly collected since the revisional work by Pritchard (1947a, 1947b, 1951). I studied this collection for a revision in progress of the Holarctic Lestremiinae. It contained six remarkable species described here as new to science. There is no further connection between these species, besides the fact that the material was sufficient enough in number of specimens and condition to describe the species with confidence. The most striking species, *Amedia floridana,* for which I erect a new genus, lacks the medial vein completely. *Allarete bicornuta* possibly supports the view that *Allarete* in its present composition is not a natural group of species. Two new species of *Neurolyga, longipes* and *pritchardi,* represent two morphological extremes among the species included in this genus. *Heterogenella californica,* the first record of this genus in North America, is the first partially brachypterous species described within the tribe Bryomyiini. *Polyardis occulta* is brachypterous in the female and the third such case within *Polyardis.*

Amedia Jaschhof, new genus

Type-species: *Amedia floridana* Jaschhof, new species, by present designation.

Adult male (female unknown).—Wings without media; R_5 reaching wing margin near wing apex; CuA unforked; CuP short; macrotrichia on both sides of R_5; antennae with 14 flagellomeres, setae and sensoria of flagellomeres not in regular whorls; dorsal transverse bridge of gonocoxites with distinct apodemes, tergum 10 free, not fused with tergite 9.

Remarks.—Apart from the lacking the media, *Amedia* best fits the diagnostic characters of the Strobliellini, where it is placed. In the monotypic genera previously belonging to this tribe, *Strobliella* Kieffer and *Groveriella* Mamaev, M_{1+2} is unforked and obsolete distally, and a long M_{3+4} is present.

Compared with the forked M_{1+2} of the Catotrichini, Lestremiini and Catochini, this is an apomorphic character, as it is the complete loss of the medial vein in *Amedia.* It should be emphasized that this loss is not combined with a general reduction of wing size, veins and macrotrichia, that accompanies brachyptery in some lestremiine genera. I hesitate to erect a unique tribe for *Amedia,* because it is known only from a single species and only the male. In addition, our knowledge of the species-poor Strobliellini is insufficient as well. With the exception of the reduction of medial veins, *Amedia* is characterized by a combination of plesiomorphic character states. The flagellum resembles that of *Catotricha* species (tribe Catotrichini) in lacking regular whorls of setae or sensoria. The male terminalia, with the comb-like structure at the apex of the gonostylus and the trapezoidal tergite 9, reminds one of some species of *Catochini.*

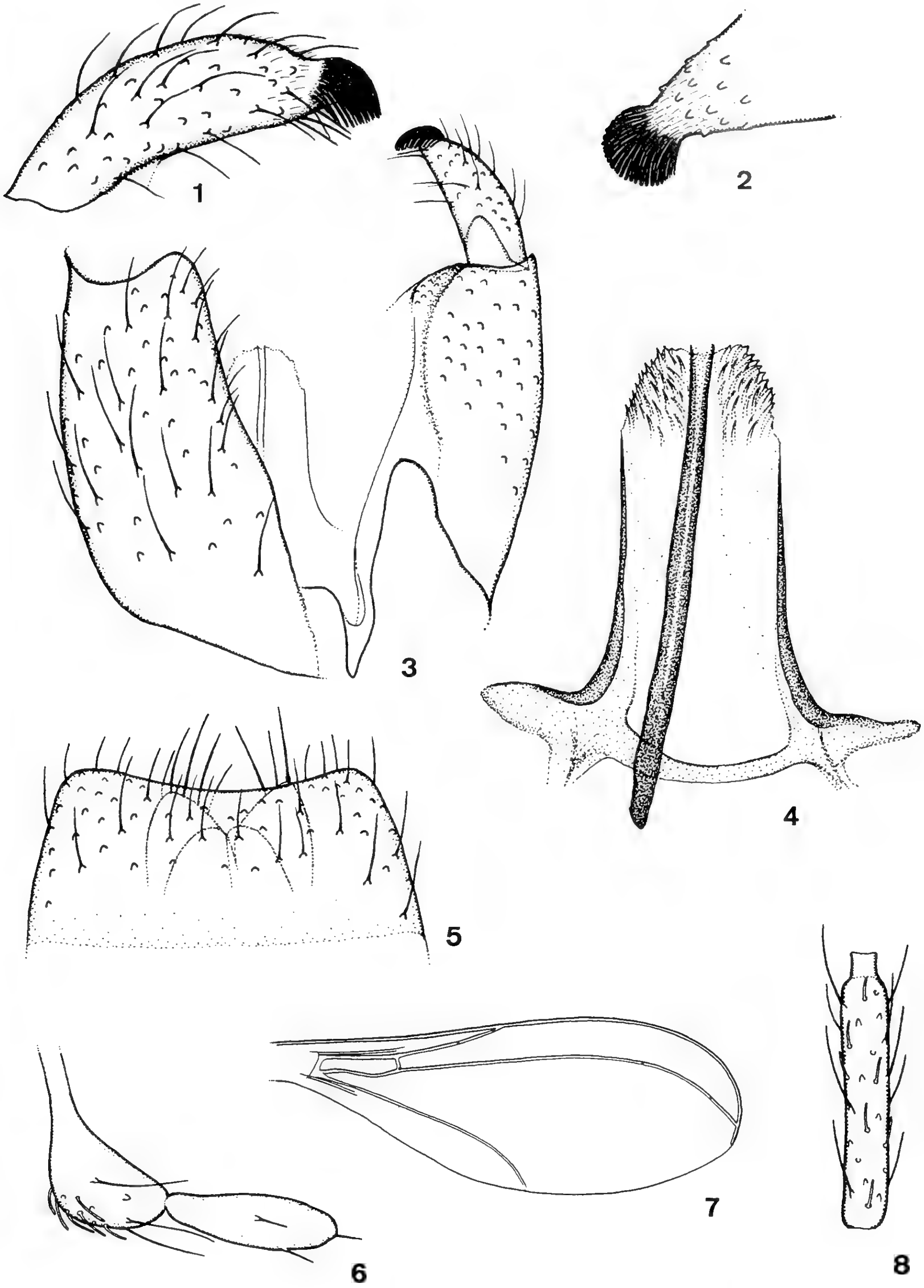
Etymology.—The name *Amedia* is of feminine gender and means "without media" referring to the unique wing venation.

Amedia floridana Jaschhof, new species
(Figs. 1–8)

Male.—Body size: 2,5–3,0 mm. *Head:* High but short, appearing flattened frontally. Postfrons bilobed, slightly prominent, with a few setae. Postcranium with sparse, scattered, long setae and no postocular bristles. Distinct suture present posterior to eye bridge and reaching occipital foramen, vertex on both sides of suture prominent. Clypeus not developed, region between insertion of antennae and mouth-parts flat and bare. Ocelli lacking. Compound eyes small; eye bridge short, strongly restricted and without facets at vertex. Antenna: scape of same size as pedicel; with 14 flagellomeres, each successively longer; fourth flagellomere (Fig. 8) with very short neck, node long, cylindrical, with irregularly scattered short setae and inconspicuous sensory hairs, fully pubescent. Palpus (Fig. 6) 2-segmented, segment 1 stemmed, with short sensory hairs ventrally and a few setae laterally, segment 2 slenderer and mostly longer than first regardless of the stem, with a few short setae. *Thorax:* Scutum with 2 lateral and 2 dorsocentral sparse rows of long setae; scutum with smooth transition into scutellum. Tarsomeres without scale-like setae. Claws very slightly bent, with minute teeth. Empodia reduced to a few hairs. Halteres with very long and narrow stem, latter with sparse setae, knob with a row of setae in prolongation of stem. Wings (Fig. 7) long and narrow; Sc extending beyond level of rs; C without distinct break near wing apex; R_1 6–7 times as long as rs; M completely lacking; CuA strong, bent distally; CuP short, close to CuA; membrane with a few macrotrichia peripherally; macrotrichia sparsely scattered dorsally on R, R_1, R_5 and ventrally on R_5. Pattern of sensory pores: R_1 1–2, rs 1 (sometimes on R_5 proximally), R_5 2–3 distally. Anal area with straight margin. *Abdomen:* Tergites and sternites with long, sparsely scattered setae concentrated along margins. Terminalia: gonocoxites (Fig. 3) with short setae ventrally, fused only in proximal fifth by a membraneous link, dorsal transverse bridge with long proximolateral apodemes; gonostylus (Fig. 1) long, slightly arched, tapering to tip (noticeable from above, Fig. 2), with a comb-like structure apically and about 5 inconspicuous ventral spines subapically; genital rod (Fig. 4) simple, narrow and sclerotized; tegmen (Fig. 4) narrow and parallel-sided, parameral apodemes swept ventrally, with basal transverse bridge, membranous on apical third and with many short hyaline "spines"; tergite 9 (Fig. 5) plate-like, nearly trapezoidal, distal margin straight or slightly emarginate, with short, scattered setae; tergum 10 free, large, bilobed, with long apical setae and covered with setulae; sternum 10 about half length of tergum 10, bilobed, with long apical setae and covered with setulae.

Female.—unknown.

Types.—Holotype ♂, I-18-1964, swept from *Medicago sativa,* Gainesville, Florida,



Figs. 1–8. *Amedia floridana,* male. 1, Gonostylus. 2, Gonostylus (detail of tip, from above). 3, Genitalia (partial, left side: ventral, right side: dorsal). 4, Tegmen and genital rod (ventral). 5, Tergite 9 and tergum 10 and sternum 10 (dorsal). 6, Palpus. 7, Wing. 8, Fourth antennal flagellomere.

U.S.A., F.W. Mead, deposited in National Museum of Natural History, Washington, D.C. Paratypes: 8 ♂, same data as holotype; 1 ♂, gopher tortoise burrow, undated, Hollister, Putnam Co., Florida, U.S.A., E.G. Milstray.

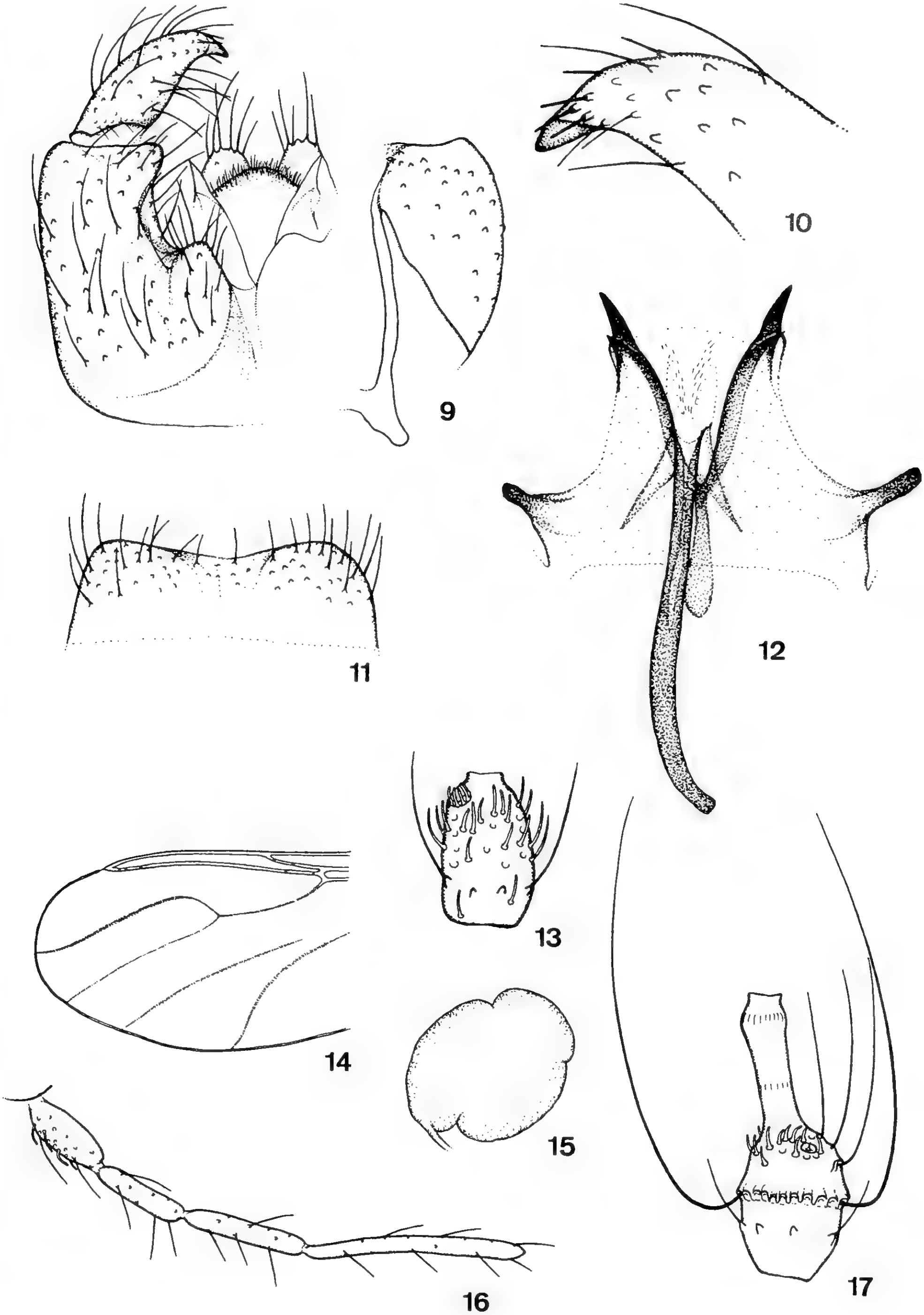
Remarks.—This unique species stands out by the combination of characters discussed under the generic description. It is further remarkable by its frontally flattened head, the lack of ocelli, and the reduced mouthparts and wing macrotrichia.

Etymology.—The name *floridana* refers to Florida, the type locality.

Allarete bicornuta Jaschhof, new species
(Figs. 9–17)

Male.—Body size: 2.5–2.7 mm. *Head:* Postfrons without setae. Eye bridge short and 4 facets long, a little constricted at vertex. Postcranium densely covered with short setae. Scape markedly larger than pedicel. Antenna with 14 flagellomeres; first flagellomere on one side covered with short sensory hairs along the whole length of node; neck of fourth flagellomere (Fig. 17) slightly shorter than node; node with 1 basal whorl of setae, mesally 1 complete crenulate whorl of extremely long setae and 2–3 short crenulate rows of long setae, distally many short sensory hairs and 1–2 large sensory spines; distal flagellomeres with gradually fewer and shorter sensory hairs. Palpus (Fig. 16) 4-segmented; segments increasingly longer distally; first segment with short sensory hairs; all segments with setae. *Thorax:* Scutum with 2 lateral and 2 dorsocentral rows of long setae. Tarsomeres without scale-like setae. Claws very short and strong, slightly arcuate; basally with several teeth, each successively longer. Empodia reduced to some hairs. Halter with setae on basal half. Wing (Fig. 14): h present; Sc not reaching level of rs; R_1 as long as in other *Allarete* species; rs and r-m very short; M-fork markedly longer than stem of M_{1+2}; M_1 broader and darker than M_2, both veins parallel-sided, diverging only distally; CuA slightly sinuous distally; CuP present; A long, apparent only in central section. Macrotrichia present on all veins with exception of h, rs, r-m and M; macrotrichia on both sides of R_5, M_{1+2} (distally) and M-fork (proximally). Pattern of sensory pores: R_1 2(–3), R_5 2 proximally, 3 distally. Anal lobe strongly convex. *Abdomen:* Tergites and sternites with long setae. Terminalia: gonocoxites (Fig. 9) with relatively short setae ventrally except on basal third and membraneous medial link, with ventral lobes, dorsal gonocoxal apodemes strong and connected by a weak transverse bridge; gonostylus (Figs. 9, 10) long, broadest at base, tapering to tip, the distal fourth arched inwards, with fingernail-like apical tooth and 4–5 short spines subapically; genital rod (Fig. 12) sclerotized, with membraneous pubescent cap apically, 2 inconspicuous acute projections from apex of genital rod directed proximolaterally; tegmen (Fig. 12) membraneous, parameral apodemes sclerotized and directed ventrally, centrally with an y-shaped sclerotization, both distal sides of y with double-toothed apex; tergite 9 (Fig. 11) wide, nearly membraneous, densely scattered with setae, distal margin straight; tergum 10 large, free, bilobed, with long and strong setae dorsally and apically; sternum 10 obviously onelobed, with rounded distal margin and covered with setulae.

Female.—Body size: 3.0–4.0 mm. *Head:* Antenna: scape little smaller than pedicel; with 9 flagellomers, the last constricted and with small second node; first flagellomere with 2 small depressions with short sensory hairs (such sensory depressions slightly noticeable also on second to seventh flagellomeres); fourth flagellomere (Fig. 13) barrel-shaped, with very short neck, 1 whorl of long setae in basal third and many short sensory hairs. *Thorax:* Tarsomeres of forelegs with many short, spine-like setae on the ventral surface (found distally on first tarsomere) and indistinct on tarsomeres of other legs. *Abdomen:* With 1 large, flattened, poorly sclerotized spermatheca (ir-



Figs. 9–17. *Allarete bicornuta*. 9, Male terminalia (partial, left side: ventral, right side: dorsal). 10, Gonostylus (detail of tip, dorsal). 11, Tergite 9 (dorsal). 12, Tegmen and genital rod (ventral). 13, Female fourth antennal flagellomere. 14, Male wing (partial). 15, Spermatheca. 16, Male palpus. 17, Male fourth antennal flagellomere.

regular margin possibly resulting from deformity, Fig. 15).

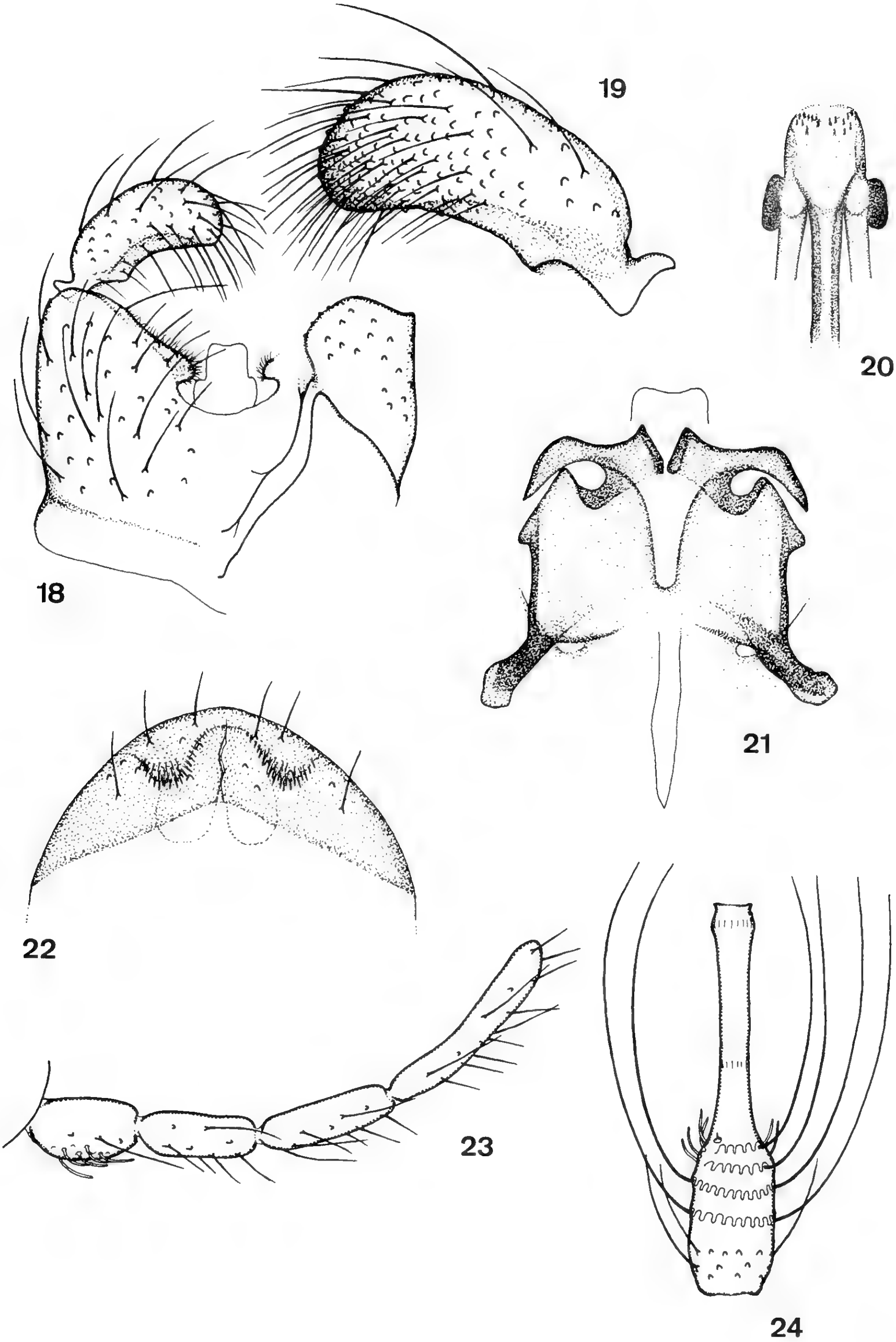
Types.—Holotype ♂, light trap, VII-16-1958, Cochise Stronghold, Dragoon Mountains, Arizona, U.S.A., C.W. O'Brien, deposited in National Museum of Natural History, Washington, D.C. Paratypes: 1 ♂ and 5 ♀, same data as holotype.

Remarks.—*Allarete* was established by Pritchard (1951) for those Lestremiini with a medial fork with branches both being of same vein width. This character is of little value, since within all species included in *Allarete* M_1 is little broader and darker than M_2 (even if not so clearly indicated as in some *Lestremia* or *Anaretella* species). Probably *Allarete* is not a natural group of species, but, in the present sense includes species with these plesiomorphic wing characters: the long R_1 and A; macrotrichia on both sides of R_5, M_{1+2} including fork and A; and 2 (not 1) sensory pores on R_5 proximally. We are not able at present to place all Lestremiini with confidence into natural groups. Therefore the new species is referred to *Allarete* with reservation and for lack of alternatives. The structure of the tegmen is unusual compared with the other congeners and within the tribe, as is the occurence of a spermatheca.

Etymology.—The name *bicornuta* is an adjective and means "with two horns" and refers to the distal projections of the tegmen.

Neurolyga longipes Jaschhof, new species
(Figs. 18–24)

Male.—Body size: 3.5 mm. *Head:* Postfrons without setae. Eye bridge with a few scattered facets laterally, medial eye portion to 4 facets long. Occiput sparsely covered with setae posteriorly. Postgenae with long setae, 1 inconspicuous row of 4–5 postocular bristles. Scape clearly larger than pedicel. Antenna with 12 flagellomeres; neck of fourth flagellomere (Fig. 24) clearly longer than node; node with 2 irregular whorls of setae basally, 1 complete and 3 incomplete crenulate whorls of long setae (distal flagellomeres with 2 complete crenulate whorls) and groups of short sensory hairs distally. Palpus (Fig. 23) long, 4-segmented, segments gradually increasing in length, first segment with short sensory hairs inside, all segments with setae. *Thorax:* Scutum with 2 lateral and 2 dorsocentral sparse rows of long setae. Legs extremely long, clearly longer than body. Claws arched at right angle, distal side longer than proximal, toothed. Empodia longer than claws. Halteres densely covered with short setae. Wings longer than body; Sc slightly reaching level of rs; rs short, R_1 10–11 times as long as rs; M_{1+2} apparent also distally; CuA_2 not reaching wing margin; CuP present, nearly ¾ as long as CuA_{1+2}. Macrotrichia on membrane and on R, R_1, R_5 and r-m (only distally). Pattern of sensory pores: R_1 3–4, rs 1, R_5 1 proximally, 1–3 medially/distally. Anal lobe clearly convex. *Abdomen:* Tergites sparsely covered with long setae, more concentrated laterally. Sternites densely covered with long setae. Terminalia: gonocoxites (Fig. 18) with a widened base without setae ventrally, otherwise with long setae except a broad stripe along medial line, distal margin with u-shaped neckline, inner bridge of gonocoxites with remarkably long setae; gonostylus (Fig. 19) long, slightly arched inwards, rounded distally, with long setae very densely covering distal third; genital rod (Fig. 20) strongly sclerotized, apically widened to membraneous head with minute hairs, mouth of sperm ducts apparently leading into head of genital rod proximolaterally; tegmen (Fig. 21) with long and sclerotized parameral apodemes, nearly parallel-sided, separated along two thirds of medial line, distolaterally with 2 characteristic angled and acute projections directed laterally; tergite 9 (Fig. 22) plate-like, slightly sclerotized, distal margin broadly rounded, distally with bilobed projection with strong, stiff, inwardly directed hair; tergum 10 fused with tergite 9, bilobed and covered with setulae.



Figs. 18–24. *Neurolyga longipes,* male. 18, Terminalia (partial, left side: ventral, right side: dorsal). 19, Gonostylus (dorsal). 20, Tip of genital rod. 21, Tegmen (ventral). 22, Tergite 9 and tergum 10 (dorsal). 23, Palpus. 24, Fourth antennal flagellomere (anterior).

Female.—unknown.

Types.—Holotype ♂, sticky trap, II-25-1976, Willamette National Forest, Oregon, U.S.A., Voegtlin & Christy, deposited in National Museum of Natural History, Washington, D.C. Paratype: 1 ♂, same data as holotype.

Remarks.—This new species is unique among the *Neurolyga* (formerly *Cordylomyia,* see below) in that the body size of the adults is much larger in relation to other species of this genus. The legs, antennae, palpi and wings are long in proportion to body size. The occurence of CuP and a distinctly convex anal lobe are plesiomorphic conditions usually not appearing within the Micromyidi. The male genitalia support the view that *Neurolyga* and *Campylomyza* form a monophyletic group. They share the medially divided tegmen with sclerotized projections, and the over all shape of the aedeagus corresponds as well. This species is referred to *Neurolyga* because of the absence of setae on the katepisternite and the lack of angled macrotrichia on wing membrane, the presence of both being synapomorphies of *Campylomyza.*

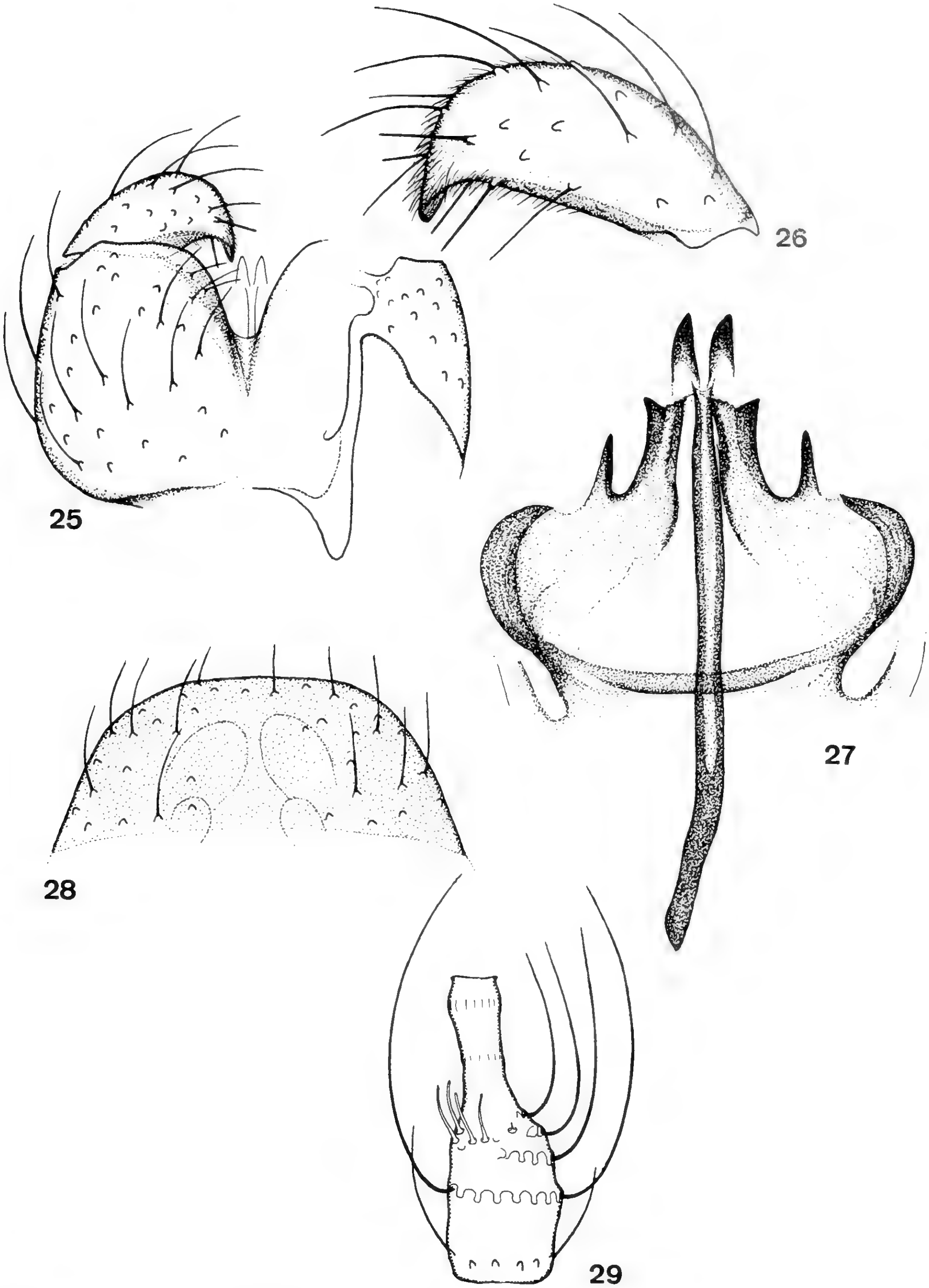
Remark on nomenclature.—I studied the remains of the original material of *Neurolyga fenestralis* Rondani, 1840, the type species of *Neurolyga,* in the Rondani collection. As a result, I consider *N. fenestralis* to be identical with *Cordylomyia coprophila* Felt, 1911, the type species of *Cordylomyia.* Consequently, *Neurolyga* is no longer considered a junior subjective synonym of *Campylomyza* Meigen, 1818, as proposed by former authors, and *Cordylomyia* Felt, 1911, is a junior subjective synonym for *Neurolyga* Rondani, 1840.

Etymology.—The name *longipes* is a noun in apposition meaning long legs.

Neurolyga pritchardi Jaschhof, new species

(Figs. 25–29)

Male.—Body size: 1.4–1.7 mm. *Head:* Postfrons without setae. Eye bridge 1 sparse row of facets long laterally, medial eye portion to 3–4 facets wide. Occiput sparsely covered with setae posteriorly; postocellar bristles indistinct. Postgenae sparsely covered with long setae, with a short row of about 3 postocular bristles. Antenna with 12 flagellomeres; neck of fourth flagellomere (Fig. 29) little shorter than node; node with 1 whorl of basal setae, 1 complete and 3 incomplete crenulate whorls of long to very long setae and groups of short sensory hairs distally. Palpus 4-segmented; last segment longest; first segment with short sensory hairs inside, very few sensory hairs also on second and third segments; all segments with setae. *Thorax:* Scutum with 2 lateral and 2 dorsocentral sparse rows of long setae. Tarsomeres without scales. Claws arched at right angle and toothed. Empodia reaching ½ to ¾ of claw length. Halter densely covered with short setae. Wing: Sc not reaching level of rs; R_1 3 times as long as rs; M_{1+2} very faint; CuA_2 short, not reaching wing margin. Macrotrichia covering membrane and on R, R_1, r-m, R_5 and CuA_{1+2}. Pattern of sensory pores: R_1 3, rs 1, r-m 1, R_5 1 medially/distally. *Abdomen:* Tergites with a few setae dorsally, more densely covered with setae laterally. Sternites with long setae. Terminalia: gonocoxites (Fig. 25) covered with long setae ventrally with exception of a stripe along the medial line, distal margin with narrow u-shaped neckline extending to more than ⅓ of gonocoxite length, dorsal transverse bridge with long apodemes proximolaterally; gonostylus (Fig. 26) arched inwards in distal third, with fingernail-like tooth apically surrounded by 4 long inconspicuous spines; genital rod (Fig. 27) long and strongly sclerotized, widened and forked apically, tips of fork sclerotized; tegmen (Fig. 27) broadest at base, parameral apodemes clearly swept ventrally, on both sides with narrow acute projection directed ventrally, distally 2 notched projections obviously seperated by a gap; tergite 9 (Fig. 28) large, plate-like, distal margin broadly rounded, with long scattered setae; tergum 10 fused with tergum 9, bilobed, densely



Figs. 25–29. *Neurolyga pritchardi,* male. 25, Terminalia (partial, left side: ventral, right side: dorsal). 26, Gonostylus (ventral). 27, Tegmen (ventral). 28, Tergite 9 and tergum 10 and sternum 10 (dorsal). 29, Fourth antennal flagellomere.

covered with setulae and a few setae; sternum 10 inconspicuous and covered with short setulae.

Female:—unknown.

Types.—Holotype ♂, IV-27-1947, Inverness, California, U.S.A., A.E. Pritchard, deposited in National Museum of Natural History, Washington, D.C. Paratype: 1 ♂, IV-27-1947, Lagunitas, California, U.S.A., A.E. Pritchard.

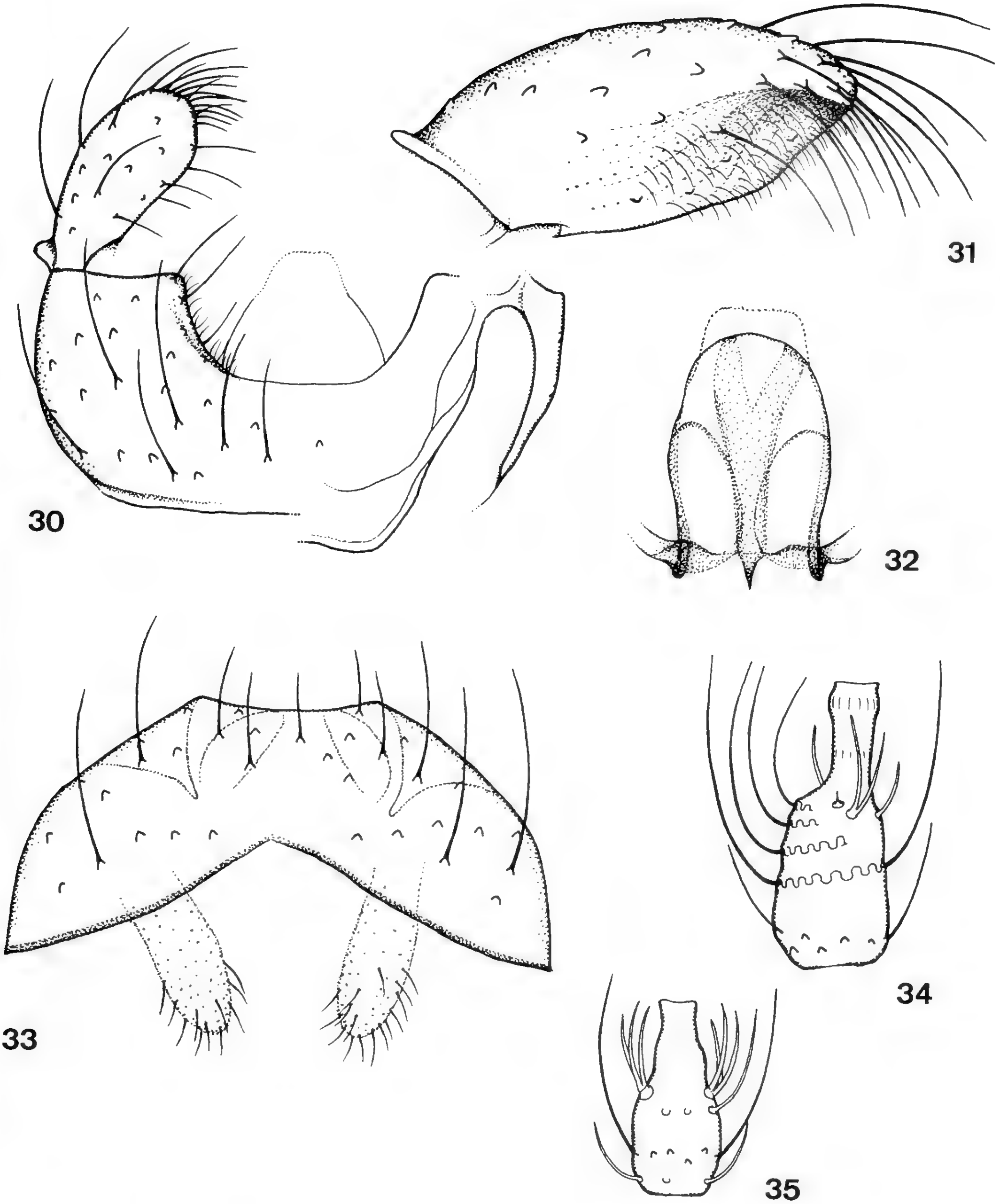
Remarks.—Within the genus the new species is unusual for the apical tooth-like structure of the gonostyli. Only one other *Neurolyga* species has that character: *N. subbifida* (Mamaev 1963) described from European Russia. I was not able to obtain material for comparative study and the description of *subbifida* is unsufficient. The sketchy available figure showing terminalia (Mamaev 1963: 452, Fig. 4 g) indicates that both species are similar in the apex of tegmen and genital rod as well. The tegmen of *N. subbifida* is described as having two diverging teeth and two further teeth of genital rod between them. This is also the case in *N. pritchardi,* but the tegmen of *N. pritchardi* has additional lateral acute projections directed ventrally. Recently I was informed by B. M. Mamaev, that *N. pritchardi* is not identical with *N. subbifida,* a decision being founded on a comparison of *subbifida* with my drawings of *pritchardi.* The new species is separated from the congeners by the short empodium and the pattern of sensory pores on wing veins: usually *Neurolyga* species have 3 pores on R_1, 1 on rs, 1 on R_5 proximally and 2 medially/distally. The pattern of pores in *subbifida* was not described.

Etymology.—The new species is named to honor A. E. Pritchard, who collected the type material, for his outstanding contributions to the taxonomy of Nearctic lestremiines.

***Heterogenella californica* Jaschhof, new species**

(Figs. 30–35)

Male.—Body size: 1.2–1.8 mm. *Head:* Postfrons without setae. Eye bridge 2–3 facets wide. Postcranium - except a stripe behind eye bridge - with long setae, postgenae also with scales. Antenna with 12 flagellomeres; neck of fourth flagellomere (Fig. 34) little to clearly shorter than node; node narrow, with 1 basal whorl of setae, 1 complete and 3 incomplete crenulate whorls of long setae and 5–6 sensory hairs of various length distally (2–4 of the them long and strong, mostly 1 bi- or three-furcated). Palpus 4-segmented; fourth segment longest; first segment with short sensory hairs inside; all segments with setae and scales. *Thorax:* Scutum with 2 dorsocentral and 2 lateral sparse rows of short setae. Tarsomeres with setae and broad scales. Claws crescent-shaped, without teeth. Empodia only just as long as the claws. Halter covered with narrow scales. Wing: Sc not reaching level of rs; R_1 2.5–3.5 times as long as rs; M_{1+2} obsolete distally; CuA-fork very acute; CuA_2 not reaching wing margin; membrane densely covered with macrotrichia and sparsely on R, R_1 proximally and CuA_{1+2}. Only 1 (not 2 as usual) sensory pore on R_5 medially/distally. *Abdomen:* Tergites with sparse row of setae dorsally and small patch of setae laterally. Sternites with long setae and scales. Terminalia: gonocoxites (Fig. 30) with long setae ventrally, distal margin with broadly u-shaped neckline, without projection on both sides of neck; gonostylus (Fig. 31) widest in distal half, clearly excavated on inside distally (noticeable only in lateral view), distal third dorsoventrally flattened and remarkably densely and strongly covered with setae, apex rounded; the base of the genital rod (Fig. 32) sclerotized, otherwise membraneous and bifurcated distally; tegmen (Fig. 32) membraneous, more or less parallel-sided, distal margin broadly rounded; tergite 9 (Fig. 33) plate-like and nearly trapezoidal (proximal margin seems to be excavated, but, this results from deformity by cover glass pressure), distolaterally 2 pointed lobes covered with setulae and directed inwards; tergum 10 fused with tergite 9 and bilobed, densely covered with long setulae;



Figs. 30–35. *Heterogenella californica.* 30, Male terminalia (partial, left side: ventral, right side: dorsal). 31, Gonostylus (dorsal). 32, Tegmen and genital rod (ventral). 33, Tergite 9 and tergum 10 and sternum 10 (dorsal). 34, Male fourth antennal flagellomere. 35, Female fourth antennal flagellomere.

sternum 10 large, bilobed, densely covered with strong setulae.

Female.—*Head:* Eye bridge shorter than in male; in brachypterous form 1–2 scattered facets long laterally and without facets at the vertex. Antenna with 8 flagellomeres, last flagellomer constricted mesially; fourth flagellomere (Fig. 35) slender, bottleshaped, with long neck; node with 1 sparse whorl of short sensory hairs basally, 1 whorl of long setae above that, 1 row of sensory hairs mesally and two 2- to 5-forked sensoria distally. Palpus 3- or 4-segmented. *Thorax:* Macropterous and brachypterous (to nearly apterous) forms occur side by side. Thorax of brachypterous form stunted, mesonotum very sparsely covered with short setae. Stubs of wing as long as thorax or clearly shorter, partly with indistinct venation and some macrotrichia at margin. Tarsomeres also of brachypterous form with broad scales. *Abdomen:* Segments with short setae. 2 small, poorly sclerotized, rounded and flattened spermathecae.

Types.—Holotype ♂, IV-27-1947, Inverness, California, U.S.A., A.E. Pritchard, deposited in National Museum of Natural History, Washington, D.C. Paratypes: 5 ♂ and 5 ♀, from redwood litter, III-18-1953, Oakland, California, U.S.A., W.C. Bentinck.

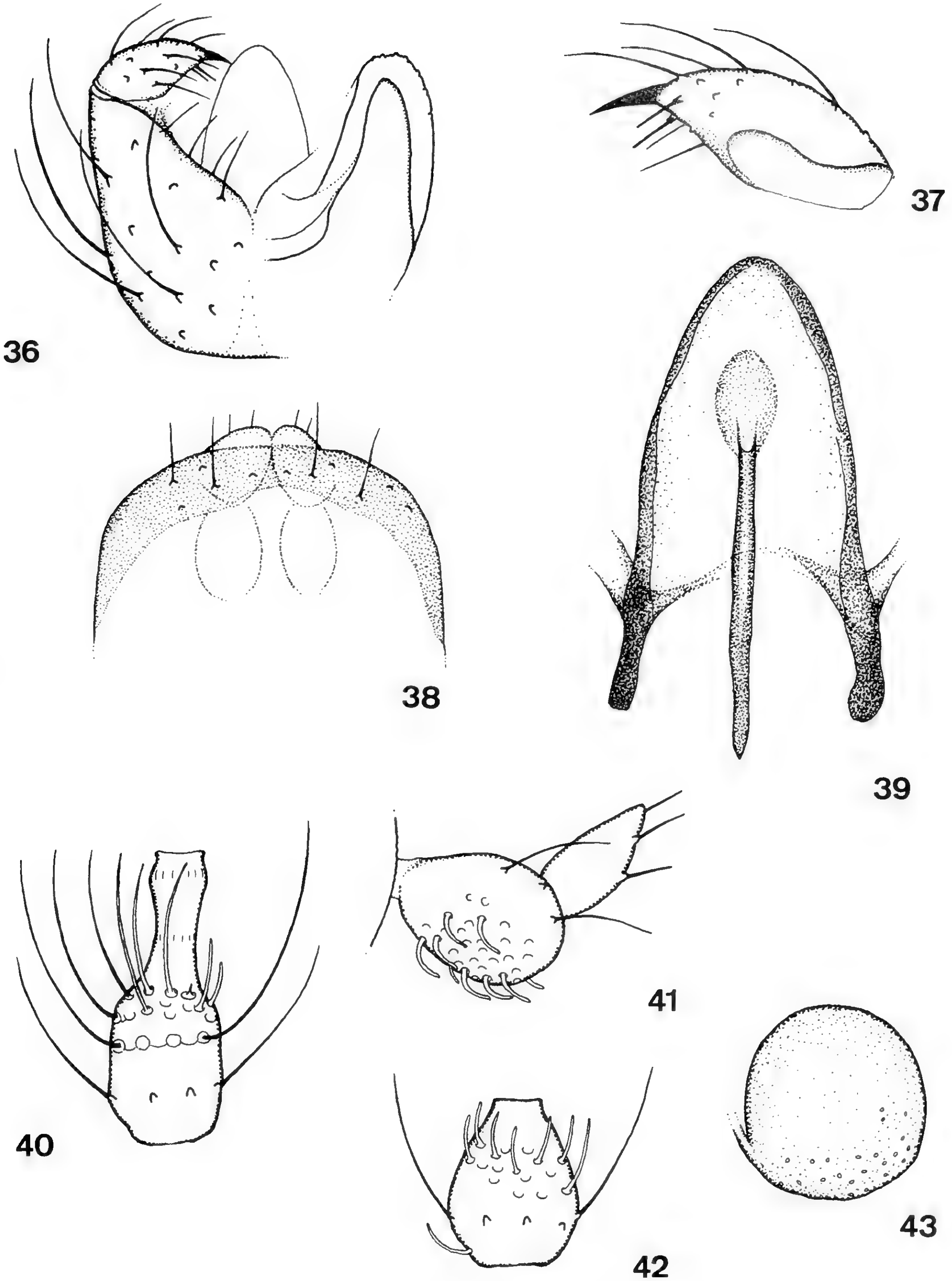
Remarks.—This is the first record of *Heterogenella* in the Nearctic Region, and *H. californica* is the only known species of the genus with wing reduction. It is remarkable that brachypterous and fully winged females occur simultaneously. The only other known female of *Heterogenella* is that of *H. bigibbata* Mamaev and Berest, resembling *H. californica* in all respects with the exception of the wing reduction. The male terminalia of *H. californica* are characterized by gonostyli widened and excavated inside in distal half and with a dense tuft of long setae apically. All other *Heterogenella* males exhibit a uniform covering with setae of gonostyli.

Etymology.—The name *californica* refers to California, the type locality.

Polyardis occulta Jaschhof, new species
(Figs. 36–43)

Male.—Body length: 1.1 mm. *Head:* Postfrons with 1 strong seta. Eye bridge 1–2 facets long laterally, 2–3 facets at the vertex. Occiput with a few strong postocellar bristles, without setae elsewhere. Postgenae sparsely covered with long setae. Antenna with 13–15 flagellomeres; neck of fourth flagellomere (Fig. 40) as long as the node or little shorter; node with 1 whorl of long basal setae, 1 complete and 1 incomplete, poorly developed crenulate whorls of long setae mesally and further setae and sensory hairs of various length distally. Palpus (Fig. 41) 2-segmented; first segment enlarged, globular, densely covered with short sensory hairs inside; second segment pointed, shorter and narrower than the first; both segments with a few setae. *Thorax:* Scutum with 2 dorsocentral and 2 lateral sparse rows of short setae. Coxae, femura and tibiae of all legs very strong; tarsomeres without scales. Claws crescent-shaped; untoothed. Empodia as long as claws. Halter sparsely covered with short setae. Wing: Sc not reaching level of rs; R_1 1,5 as long as rs; CuA_2 strong, but short; wing membrane without macrotrichia, R, R_1 and R_5 with a few macrotrichia only. *Abdomen:* Tergites with a few setae only laterally. Sternites densely covered with long setae. Terminalia: gonocoxites (Fig. 36) with long to very long setae ventrally, distal margin with broadly v-shaped neckline; gonostyli (Fig. 37) small, broadest in proximal third, sharply tapering to tip, with 1 long, slender apical tooth and 2 inconspicuous ventral spines subapically; genital rod (Fig. 39) slender, opening in distal fifth, somewhat widened (ovoid) and lightly sclerotized apically; tegmen (Fig. 39) shield-shaped, with rounded apex; tergite 9 (Fig. 38) with narrow sclerotized posterior margin and scattered setae; tergum 10 fused with tergite 9, bilobed, densely covered with setulae and with a few fine setae; sternum 10 hidden, bilobed and covered with setulae.

Female.—Body size: 1.2 mm. *Head:* Eye bridge 1–2 rows of scattered facets long. Postcranium sparsely covered with setae. Antenna with 9 flagellomeres; first flagellomer with field of many short sensorial hairs on prolonged basis; fourth flagellomer (Fig. 42) tapering in distal half, with inconspicuous neck; node with a few sensory



Figs. 36–43. *Polyardis occulta.* 36, Male terminalia (partial, left side: ventral, right side: dorsal). 37, Gonostylus (dorsal). 38, Tergite 9 and tergum 10 and sternum 10 (dorsal). 39, Tegmen and genital rod (ventral). 40, Male fourth antennal flagellomere. 41, Male palpus. 42, Female fourth antennal flagellomere. 43, Spermatheca.

hairs and 1 whorl of setae basally and many short sensory hairs apicad of the setae. First segment of palpi stronger enlarged than in male. *Thorax:* Stunted in size; mesonotum with a few short setae only. Brachypterous; wings noticeable as short stubs without venation. Fifth tarsomere of forelegs twice as long as fourth. *Abdomen:* Setae very short. 1 large, sclerotized, disc-shaped spermatheca (Fig. 43), on one side with many small pores.

Types.—Holotype ♂, shrubby meadow, VII-15 to VIII-28-1977, 18 km east of Gananogue, Ontario, Canada, Dondale & Redner, deposited in National Museum of Natural History, Washington, D.C. Paratypes: 2 ♂ and 2 ♀, same data as holotype.

Remarks.—The species represents the third case of brachyptery in the female within *Polyardis* beside *P. silvalis* (Rondani) and *P. recondita* (Lengersdorf) (Jaschhof, in prep.). Like other wing reduced species in different genera, *P. occulta* exhibits characters frequently connected with brachyptery or aptery beside the remarkable reduction of the thorax. These are the reduced vestiture on the head and mesonotum, the reduced number of facets of the eye bridge, shortened palpi and partially broadened legs. The winged male is partly affected as well, not only by the shortened palpi, but, also by a reduced vestiture with macrotrichia on the wing and the poorly developed crenulate whorls on the flagellomeres. The new species is the only *Polyardis* species with 2-segmented palpi, an exceptional character within the whole subfamily Lestremiinae. The male genitalia are of the usual type and similar to the congeners, but the gonostyli are small and sharply tapered with a longer and slenderer apical tooth compared to other species. In addition, the genital rod opens in the distal fifth and exhibits an ovoid widening apically.

Etymology.—The name *occulta* is an adjective and means occult, referring to the combination of exceptional characters, especially in female sex.

Remark on nomenclature.—*Polyardis* Pritchard, 1947 is not a junior subjective synonym of *Campyloneura* Lengersdorf, 1939, as I previously considered it to be (Jaschhof and Menzel 1995). Recently I was informed by Mr. K. Voigt, Ettlingen, that *Campyloneura* is a preoccupied name (by *Campyloneura* Fieber, 1860, in Miridae, Heteroptera).

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MORPHOLOGICAL CHARACTERISTICS OF THE STING AND PREY CARRIAGE MECHANISM IN *SERICOPHORUS RELUCENS* F. SMITH (HYMENOPTERA: SPHECIDAE: LARRINAE)

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Abstract.—Morphological characteristics of the sting concerning prey carriage in *Sericophorus relucens* F. Smith are described. The sting apparatus consists of sting palpi (with bristles), stylet, and lancets, with different morphological adaptations. Correlation between the morphological features of some parts of the sting and their function in prey carriage are discussed.

Key Words: *Sericophorus relucens* F. Smith, Sphecidae, prey carriage, sting morphology

There are basically three types of prey carriage in the Sphecidae: mandibular, pedal, and abdominal, each with several subtypes. The most primitive one is mandibular (found in the majority of Sphecidae species), and the more advanced are pedal (found in four groups of this family) and abdominal (found in three groups of this family) (Evans 1962). The abdominal type of prey transport includes three subtypes: abdominal transport with the use of a specially modified apical abdominal segment, "buprestid clamp" subtype, a modification of the fifth abdominal sternum, and abdominal transport with the use of the sting.

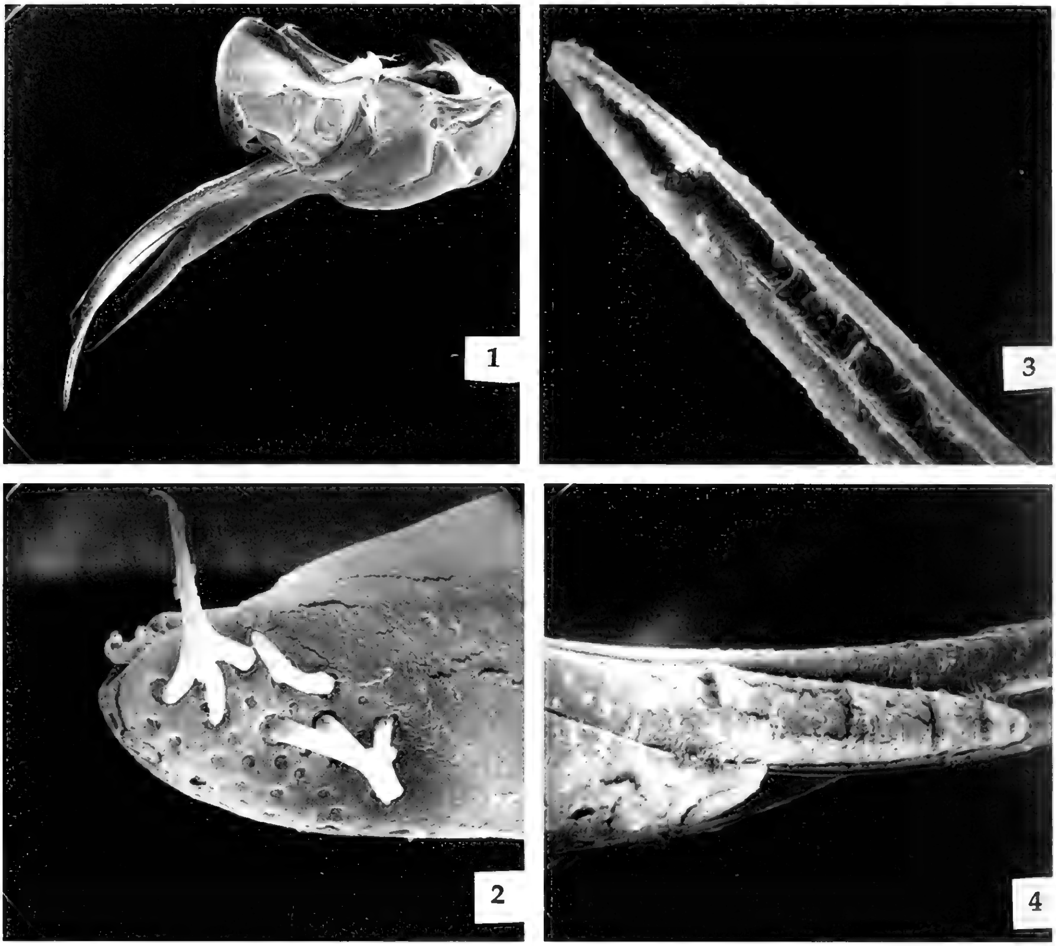
The first subtype is found in *Listropygia* and *Clypeadon* (Philanthinae), and is characterized by a modified apical abdominal segment in the form of a clamp (Evans 1962; Bohart and Menke 1976).

The second subtype is found in certain *Cerceris* species (Krombein 1981).

The third subtype is found in some Crabroninae (*Oxybelus* sp., *Crossocerus* sp.) (Evans 1962) and in *Sericophorus relucens* F. Smith (Larrinae) (McCorquodale 1988). McCorquodale (1988) first reported sting prey carriage in a species outside the Crabroninae, *S. relucens,* the first found in Larrinae which is one of the most advanced prey transport mechanisms.

Most of the Sphecidae that use their sting apparatus for prey transport exhibit some adaptive changes in the morphology of several structures of the sting, mainly the stylet, that are correlated to sclerotisation and mobility of their prey (Radovic 1985). Those changes in general are a curved stylet in sphecids that prey on fast flying insects; a slightly curved or straight stylet in those praying on slower insects. The presence of bristles on the distal part of palpi and presence of barbs on the distal part of lancets function in securing prey impaled on the stylet.

Sericophorus relucens preys upon Diptera (Matthews and Evans 1970; Peckham and Hook 1980). They sting their prey in the air, on the ventral side of the thorax, and keep it impaled on the sting, not removing it while flying, till they get to the nest (McCorquodale 1988).



Figs. 1–4. *Sericophorus relucens.* 1, Lateral view of the sting apparatus (SEM, 65×) (original). 2, Tip of the palpus (SEM 100×) (original). 3, Tip of the stylet (SEM, 100×) (original). 4, Lancet barbs positioned in lancet tracks (SEM, 100×) (original).

MATERIALS AND METHODS

We examined five specimens obtained from Dr. O. Lomholdt (Zoologisk Museum, Copenhagen), from Blue Mountains and Kurrajong, New South Wales; Mount Wedge and Mundiwindi, Western Australia.

The sting apparatuses (Fig. 1) were first removed from the abdomen of the specimens, and initially preserved in glycerol. They were cleaned for scanning electron microscopy (SEM) by soaking in 1:1 solution of ammonium hydroxide and water, dehydrated in ethanol, soaked in chloroform, and air dried. We fixed them to the SEM stubs using silver conducting paint. A "sputter coater" was used for gold coating the objects (Gibson 1984). The stings were filmed using "Foma" (5 × 5 cm) film.

RESULTS

Examining five specimens of *S. relucens,* we found the following elements of the sting apparatus:

1. Sting palpi.—Two sting palpi consisting of two segments are present (Fig. 1). Several (commonly around ten) bristles are found on the tip of the distal part (Fig. 2). Bristles are distributed along the horizontal axis of the palpus tip forming two groups: longer bristles (on the distal part of the tip)

and shorter bristles (on the sides of the tip). The bristles are unsegmented, rough surfaced, straight with slightly enlarged base. Similar bristles are found on the side of the proximal segment of the palpi.

2. Stylet.—The stylet (Fig. 3) is long and curved (less than in *Oxybelus* species) with a sharp pointed tip. The surface and edges of the stylet are rough, covered with tubercles, and different in shape and size. The lancet tracks, concavely shaped with no special structures (like olistheter scales or setae found in Vespidae, Ondricek-Fallscheer 1992), are located on the ventral side of the stylet, and covered with larger tubercles. The cracklike poison duct is located near the tip of the stylet.

3. Lancets.—A pair of lancets is located on the ventral side of the stylet. We found unexserted lancets in all of the examined specimens. Lancets are sharply pointed and covered with small tubercles. Similar to some crabronine sphecids, the lancets of *S. relucens* are barbed (Fig. 4). Six barbs are positioned on the dorsal side and form a line parallel to the longitudinal axis of the lancet. The barbs differ in size: those closer to the lancet's tip have smaller dimensions in contrast to those with proximal position that are particularly wider at their base. No variation was found in the number of barbs between the two lancets and among different specimens. Sensilla campaniformia were not noted.

DISCUSSION

Regarding morphological and behavioral characteristics, the type of prey carriage found in *S. relucens* belongs to the abdominal "sting" type that is found only in two other genera of Sphecidae and is considered to be one of the most advanced (Evans 1962).

Most of the features of the sting apparatus examined in our research show correlation between their morphological characteristics and their function in prey carriage, generally in securing contact of the sting with the body of the victim.

Sting palpi are provided with receptory bristles that can also function in holding the body of the prey. The majority of sphecids that prey upon fast fliers (Diptera, Hymenoptera) have a curved stylet (Radovic 1985). The stylet of *S. relucens,* although it preys upon Diptera, is not extremely curved (compared to that in *Oxybelus* species), probably due to light prey preference. Numerous tubercles on the sides and edges of the stylet function in increasing the stylet surface that is in contact with the victim's internal tissues. As the lancet barbs are positioned dorsally, the sharp pointed stylet tip probably does not function in severing parts of the victim's tissues caught in the lancet barbs.

The function of lancets is anchoring the stylet in the body of the victim (Ondricek-Fallscheer 1992). We found no lancets in exserted position in all specimens examined, so we could not ascertain whether the lancets protrude beyond the tip of the stylet. Dorsally positioned barbs have a function in securing prey impaled on the sting (Radovic 1985).

Most of the listed structural modifications are correlated to complex behavior patterns of this species. Predatory insects that use their sting for prey carriage share several important advantages to those that use mandibles or legs. Positioning the prey in the back, wasps shift their gravitational center that is important in maintaining overall balance; this type of carriage permits rapid provisioning of the nest that positively affects the prey searching distance, provides fewer opportunities for predators and parasites to attack the prey, and leaves the mandibles and legs free for use otherwise (after Evans 1962).

CONCLUSIONS

There are three basic types of prey carriage in the family Sphecidae: mandibular, pedal and abdominal, each with several subtypes. The abdominal type of prey transport includes three subtypes one of which is abdominal transport with the use of the sting, such as that found in *S. relucens.*

Using SEM we found the following in *S. relucens:* two sting palpi consisting of two segments with approximately ten receptory bristles distributed along the palpus tip that also function in securing prey impaled on the sting and the long and curved stylet with a sharp pointed tip, covered with tubercles which are different in shape and size, and provided with two lancet tracks; lancets, positioned on the ventral side of the stylet, and embedded in lancet tracks, are sharply pointed and covered with small tubercles, six barbs are found on the dorsal side of the lancets.

Most of the structural characteristics examined serve in securing firm contact of the sting with the body of the victim.

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BIOLOGY OF FOUR SPECIES OF *NOTIPHILA* FALLÉN (DIPTERA: EPHYDRIDAE) ASSOCIATED WITH THE YELLOW WATER LILY, *NUPHAR LUTEUM* (NYMPHAEACEAE)

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Abstract:—The life histories of four species of *Notiphila, N. bella, N. eleomyia, N. kentensis,* and *N. nudipes,* that feed on anaerobic sediments surrounding roots of the yellow waterlily, *Nuphar luteum,* are described. Males of *N. eleomyia* and *N. nudipes* form mating aggregations resembling leks on flower buds, flowers, fruits, and occasionally leaves of the host plant, and mating occurs within these aggregations. Females deposit large clusters of eggs on these plant parts, particularly the flowers and fruits. The incubation period lasts 4–6 days, and newly hatched larvae drop off the egg masses and fall into the underlying sediments where they feed during the summer and fall months. Overwintering occurs as nearly mature larvae. In late May and early June, larvae move to roots of *Nuphar* and insert their spiracular spines into air spaces within the root tissue. The pupal period lasts 14–22 days. *Notiphila bella* is univoltine, but the three other species may be bivoltine. Information is presented on the utilization of wetland plants by different species of *Notiphila,* and it is proposed that speciation and adaptive radiation involved movement onto these different "host plants" for the purpose of obtaining oxygen by the larvae.

Key Words: Shore flies, *Notiphila,* Ephydridae, Diptera, *Nuphar,* Ohio

Wetlands subjected to long-term inundation develop anaerobic conditions in the underlying soils (Mitsch and Gosselink 1992). As a result, plants and animals living in such anaerobic conditions must acquire a variety of mechanisms that allow them to acquire the oxygen necessary for their metabolic functions. Many wetland plants possess aerenchyma in their stems, rhizomes, and roots that allows for the diffusion or mass transport of oxygen from the photosynthesizing aerial portions of the plant to the roots (Armstrong 1964, 1978; Dacey 1980, 1981; Grosse and Mevi-Schutz 1987; Mevi-Schutz and Grobe 1988). Larvae of some insects living in anaerobic soils have modified posterior spiracles that form elongate spines that can be inserted into the aerenchymatous tissues of plants and thus acquire oxygen (Müller 1922; Varley 1937, 1939; Keilin 1944; Hinton 1953. 1968; Hartley 1958; Houlihan 1969a, 1969b). A large and widely distributed taxon having this ability are shore flies belonging to the genus *Notiphila* Fallén.

The genus *Notiphila* is worldwide in distribution, occurs in a variety of wetland habitats, and is speciose, with 53 species having been recorded from America north of Mexico (Mathis 1979, Wirth et al. 1987). Meaningful biological studies are available for only five of these Nearctic species, although fragmentary information has been published for an additional 15. Berg (1950) reared *N.* (*Notiphila*) *loewi* Cresson from anaerobic soils surrounding the rhizomes and roots of pondweeds (*Potamogeton* spp.). Eastin and Foote (1971) discussed the natural history of *N.* (*Dichaeta*) *caudata* Fallén, a species that is unusual within the genus in that its larvae are not buried in anaerobic sediments but crawl about on the surface. Larvae of this species lack spiracular spines. Busacca and Foote (1978) presented life history observations on two species, *N.* (*Agrolimna*) *aenigma* Cresson, and *N.* (*N.*) *solita* Walker, that obtain oxygen from roots of cattails (*Typha latifibula* L.). They also described the eggs, larvae, and puparia of these two species. Deonier et al. (1978) described the immature stages and outlined the natural history of *N.* (*N.*) *carinata* Loew, a species that is associated with water willow (*Justicia americana* (L.) Vahl.) growing in slow-flowing streams in southwestern Ohio and other regions east of the Mississippi River.

Some biological observations and indications of association with particular wetland plants are also available for *N.* (*N.*) *bella* Loew, *N.* (*N.*) *eleomyia* Mathis, *N.* (*N.*) *kentensis* Huryn, *N.* (*N.*) *mathisi* Huryn, *N.* (*N.*) *nudipes* Cresson, *N.* (*N.*) *pauroura* Mathis, *N.* (*N.*) *poliosoma* Mathis, *N.* (*N.*) *shewelli* Mathis, *N.* (*N.*) *taenia* Mathis, *N.* (*N.*) *theonae* Huryn, and *N.* (*A.*) *deonieri* Mathis, *N.* (*A.*) *olivacea* Cresson, *N.* (*A.*) *quadrisetosa* Thomson, *N.* (*A.*) *scalaris* Loew and *N.* (*A.*) *scoliochaeta* Mathis (Mathis 1979; Todd and Foote 1987; Huryn 1984, 1987).

In this paper, we present observations of the natural history of *Notiphila bella, N. eleomyia, N. kentensis,* and *N. nudipes* occurring in stands of the yellow water lily, *Nuphar leuteum* (L.) Sibth. and J. E. Smith. We also discuss resource partitioning in the genus *Notiphila* and propose a possible mode of speciation within this taxon.

MATERIALS AND METHODS

Site description.—Two marshes located in Portage County in northeastern Ohio (Fig. 1) were sampled in this study. The larger marsh is situated on the east side of State Highway 43, 9.3 km north of the northern city limits of Kent. The marsh is bordered on the west by the highway, residential property on the north, and open lowland woodlands on the east and south. The emergent marsh vegetation consists of species of *Carex, Typha,* and *Sparganium* around the perimeter, a large stand of *Typha* and *Sparganium* growing intermixed on a floating mat of dead vegetation at the east end, and a large stand (ca. 2700 m^2) of yellow water lily at the west end (Fig. 2). In addition to the emergent vegetation, there are thick growths of floating duckweeds, *Lemna minor* L., *Wolffia punctata* Griseb., *Spirodela polyrhiza* (L.) Schleid., and water milfoil, *Myriophyllum exalbescens* Fernald. The marsh is persistent and has a rather stable water level. The water depth varied from 50 to 80 cm during the two-year study period.

The second, much smaller marsh is located 0.8 km east of the Kent State University main campus, between Horning Road and U.S. Highway 261 (Fig. 3). It is bordered by Horning Road on the west, residential property and a pond on the north, Highway 261 on the east, and an abandoned agricultural field on the south. The vegetation is more diverse than in the larger marsh and consists of discontinuous stands of *Typha, Carex, Phalaris, Sparganium, Eleocharis,* and *Nuphar.* At the time this marsh was characterized by Todd and Foote (1987), the *Nuphar* stand encompassed some 1157 m^2, but low water levels since that survey has permitted *Typha* to invade. As a result, the continuous stand of *Nuphar* in 1995 is only some 100 m^2, and the water depth averages only 10 cm.

Sampling methods for adults.—A transect was established across the center of the *Nuphar* stand at the Route 43 marsh (Fig.

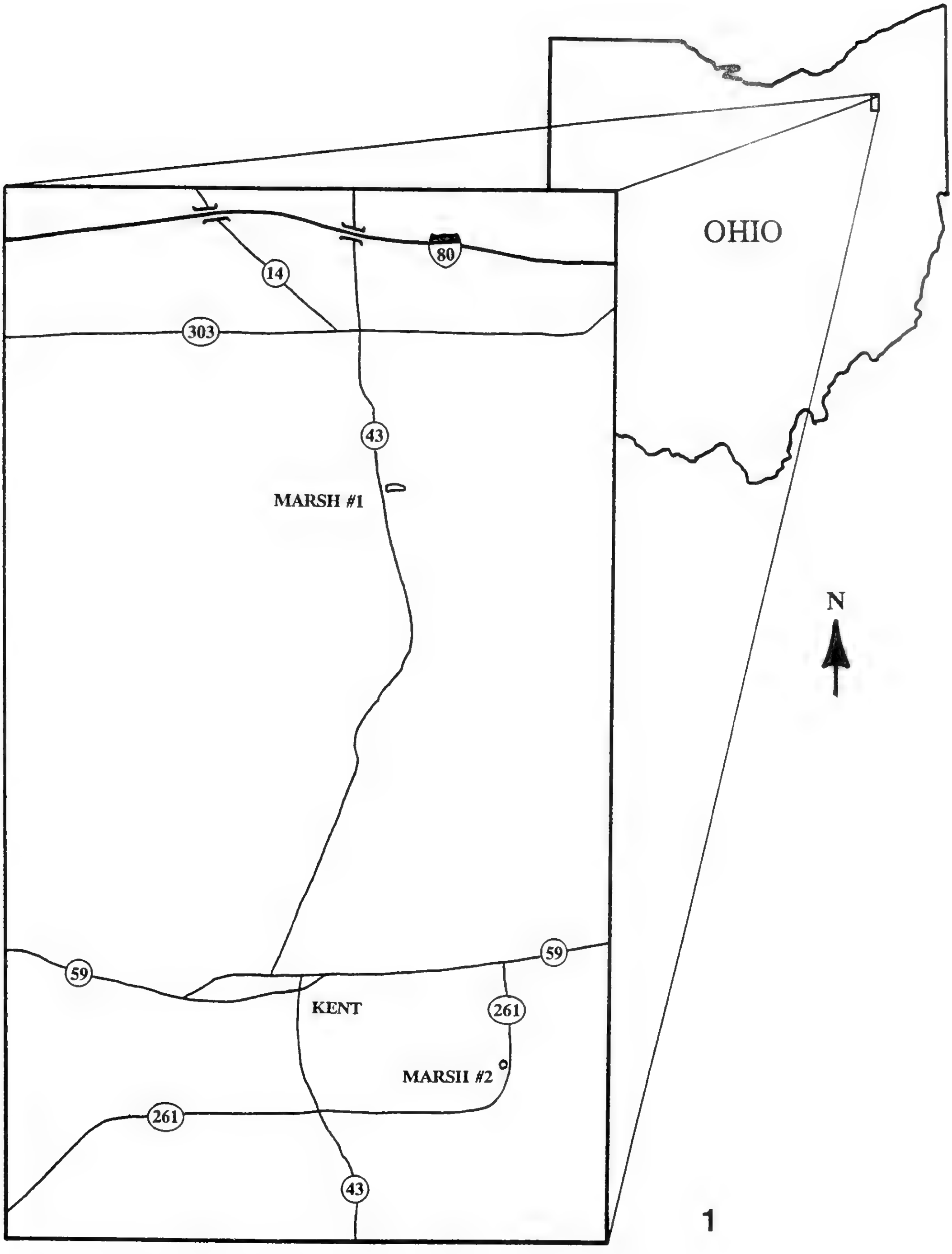
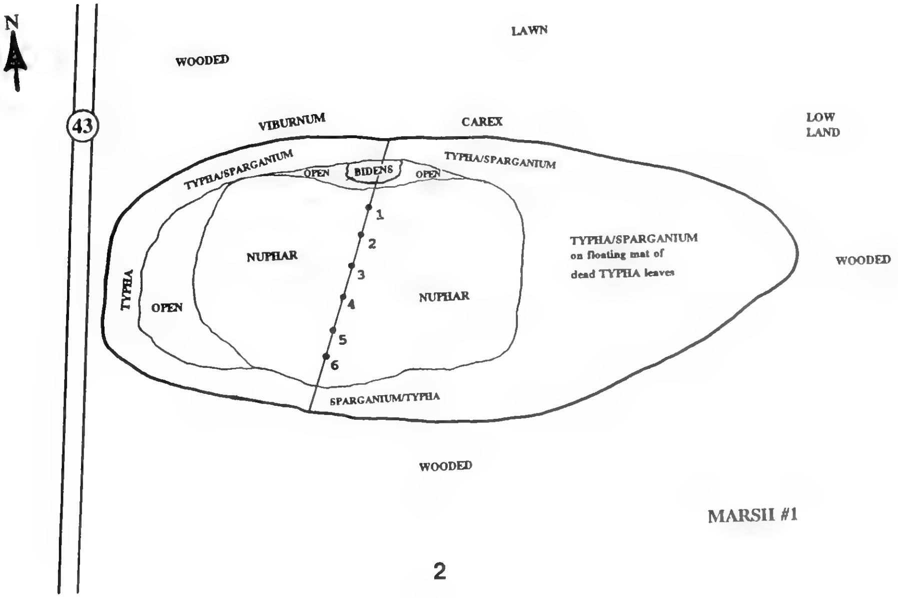


Fig. 1. Map showing locations of two study marshes in northeastern Ohio.



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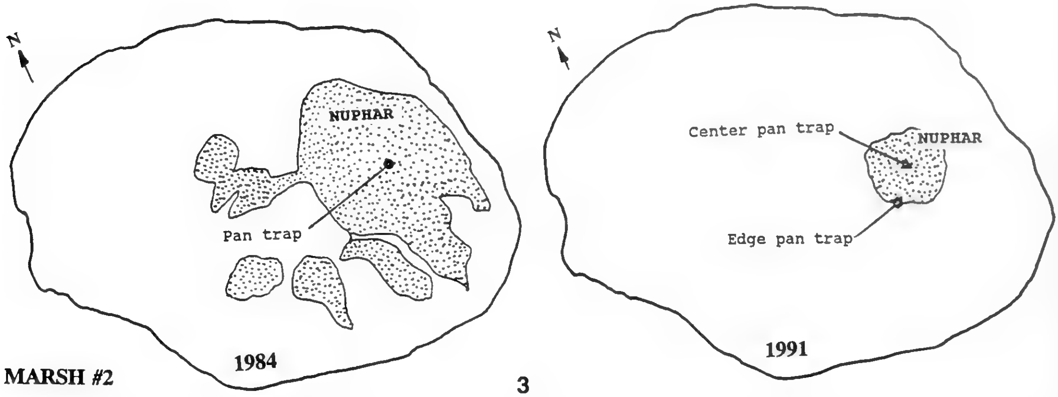

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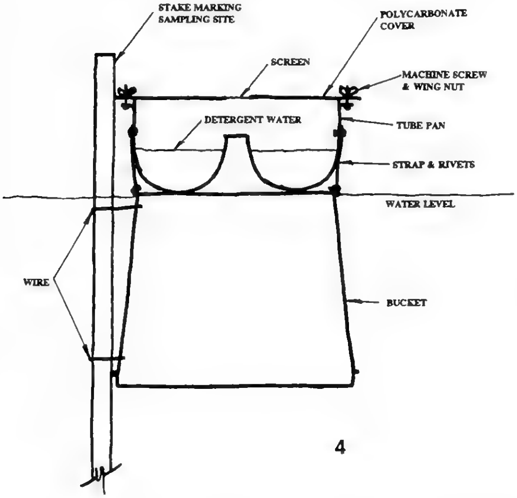
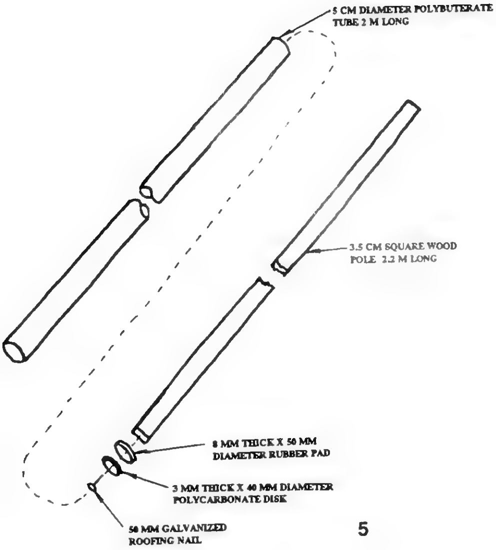
Figs. 2–3. 2, Map of the Route 43 marsh showing stands of vegetation. 3, Map of Horning Road marsh showing stands of *Nuphar luteum*.

2). The transect extended south-southeast from the north edge of the marsh. A rope, 65 m long, that was attached at each end of the transect completely crossed the width of the marsh. The *Nuphar* stand along the transect was 45 m wide. Six sampling sites were established along the transect at 6 m intervals. Each site was marked by wooden stakes that encompassed a 4 × 2 m plot. Two sampling sites were established in the Horning Road marsh (Fig. 3). One of these was in the center of the *Nuphar* stand, the other some 5 m distant where *Nuphar* and *Typha* were intermixed.

Collections of adult *Notiphila* were taken weekly at 2 locations in each marsh between early June and early October from 1991 to 1993. All collections were made during the same 24 hour period using identical detergent pan traps (Southwood, 1978). The pan traps consisted of white polyethylene storage containers measuring 30 × 15 × 10 cm. Each trap contained approximately 50 ml of water into which one ml of dishwashing detergent had been added. All traps were placed in the marshes during the mid-afternoon and collected 24 hours later. In the Route 43 marsh, traps





Figs. 4–5. 4, Emergence trap, cross-section diagram. 5, Diagram of core sampling device.

were placed at sampling sites 1 and 3, whereas in the Horning Road marsh, they were placed at both collecting sites. The contents of the traps were returned to the laboratory where the adult *Notiphila* were removed, identified, sexed, and counted.

Collections of adult *Notiphila* from the unopened buds or flowers of the *Nuphar* were obtained either by using a modified battery-operated hand vacuum (Marshall 1982) or by carefully placing a large polyethylene bag over the buds or flowers and then breaking off the peduncle below the water surface and sealing the bag.

During the summer of 1992, six emergence traps were placed along the transect in the Route 43 marsh, one trap at each end of the sample plots. The traps were constructed by attaching a one-piece plastic tube pan to the outside bottom of a plastic 3-gallon (11.25 L) bucket (Fig. 4). Prior to attaching the pan, a small hole was cut in the center of the bucket. A lid of clear, polycarbonate plastic was attached to the bucket with machine screws and wing nuts. A 5 cm vent hole was cut in the center of the lid and covered with plastic window screening. The two holes allowed for venting but prevented rainwater from flooding the trap. Traps were attached to the wooden stakes delimiting the sample plots and the bucket part of each trap was completely submerged. Each tube pan contained approximately 500 ml of water and one ml of detergent. The traps were emptied weekly between June 15 and July 27, 192, and the *Notiphia* identified, sexed, and counted.

Sampling methods for larvae.—Core samples of the bottom substrates were taken at the sample sites in the Route 43 marsh on September 20, 1991 (site 1), February 18, September 25, October 8, 1992, and April 6, 1993 (all six sites). Cores were obtained using a 5 cm colorless, polybuterate tube that was 2 m long (Fig. 5). A piston fitted into the coring tube allowed the substrate to be sampled without being flooded by the overlying water. Cores were placed in polyethylene bags and returned to the laboratory where they were examined for *Notphila* larvae. Larvae were extracted from the cores either by using an elutriator similar to that described by Whitman et al. (1983) or adding water to the mud sample to reduce it to a slurry that was then spread over the bottom of a large tray and inspected visually.

Rearing methods.—Portions of *Nuphar* rhizomes and attached roots were removed from the marsh substrate at various times throughout the year and examined visually in the laboratory for attached larvae and/or puparia. Puparia were carefully removed from the roots and placed on moist sphagnum moss in test tubes (Berg 1950). They were oriented in the moss so that the posterior spiracular spines of the puparia were exposed to air. No attempt was made to rear larvae.

Identification of adults.—Males were determined by using keys of Mathis (1979) and Huryn (1987). Tentatively determined specimens of each species were submitted to Wayne Mathis at the Smithsonian Institution for confirmation.

RESULTS OF TRAPPING IN THE TWO MARSHES

Pan trapping in the Route 43 marsh.—Approximately 53,200 adult *Notiphila* of eight species (Table 1, Fig. 6) were obtained in the detergent pan traps during the three-year survey. Of these, 10,620 (20.4%) were males. Three species, *N. eleomyia, N. kentesis,* and *N. nudipes* dominated throughout the study (Figs. 7–9), representing 95.2% of the total number collected. These three, plus *N. bella,* constituted over 97% of the males collected. *N. eleomyia* was the most abundant species, accounting for 60.3% of the total number. The second most abundant species was *N. kentensis,* accounting for 25.5% of the males collected, whereas *N. nudipes* accounted for only 9.4% of the males identified. *Notiphila bella* was present only during late spring and early summer and commonly was the first species to emerge (Fig. 10). Four other species, *N. olivacea, N. pauroura* Mathis, *N. solita,* and *N. taenia,* were only collected sporadically. *Notiphila taenia* was taken predominantly from mid to late June, although a few were taken as late as October. The other three species were taken irregularly throughout the summer months.

Table 1. Temporal distribution of adults of all species of *Notiphila* collected in two marshes in Portage County, Ohio.

Week number	Route 43 marsh 1991	Route 43 marsh 1992	Route 43 marsh 1993	Horning Road marsh 1991
19	*	*	—	*
20	*	*	—	*
21	*	*	41	*
22	*	*	544	*
23	*	1451	3898	*
24	*	4309	10,410	*
25	2850	2052	8864	254
26	1925	1370	3524	79
27	1056	3316	*	66
28	381	*	*	4
29	233	2322	*	2
30	131	617	*	3
31	122	337	*	—
32	440	160	*	—
33	219	174	*	—
34	*	95	*	*
35	66	372	*	—
36	58	338	*	—
37	50	*	*	—
38	8	131	*	—
39	2	67	*	—
40	24	*	*	—
41	*	*	*	*
42	*	116	*	*
Totals	7565	17,386	27,274	408

* No collections made.

Forty-nine percent of the adults were taken in pan traps located near the center of the *Nuphar* stand (site 3), and 51% from the edge of the stand (site 1) (Fig. 11). The only species that did not follow this distributional pattern was *N. pauroura,* as only 25% of its adults were taken in the centermost traps.

The species composition of *Notiphila* remained fairly stable over the three years, but abundances changed considerably. The total number of individuals collected in 1991 was 7565, but this increased every year to the 27,275 trapped in 1993 (Fig. 12). The maximum number of flies trapped over a 24-hour period (Fig. 12) occurred

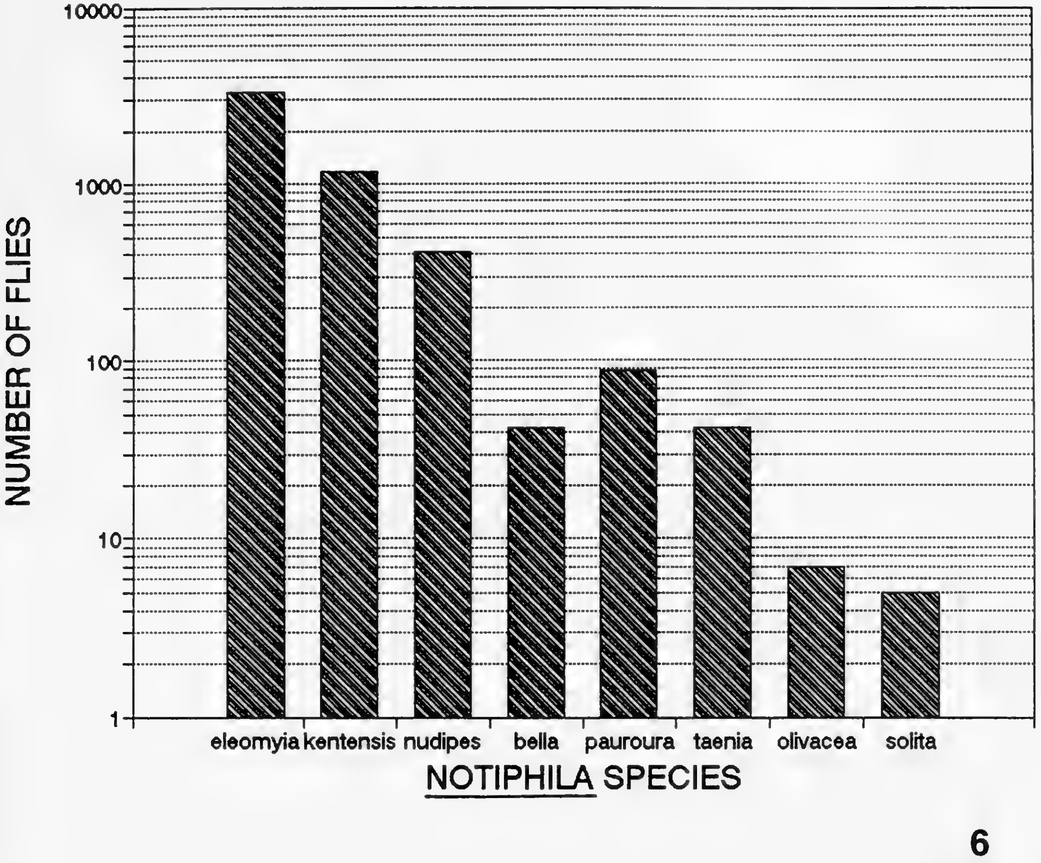


Fig. 6. Total number of *Notiphila* males collected in the Route 43 marsh during 1992.

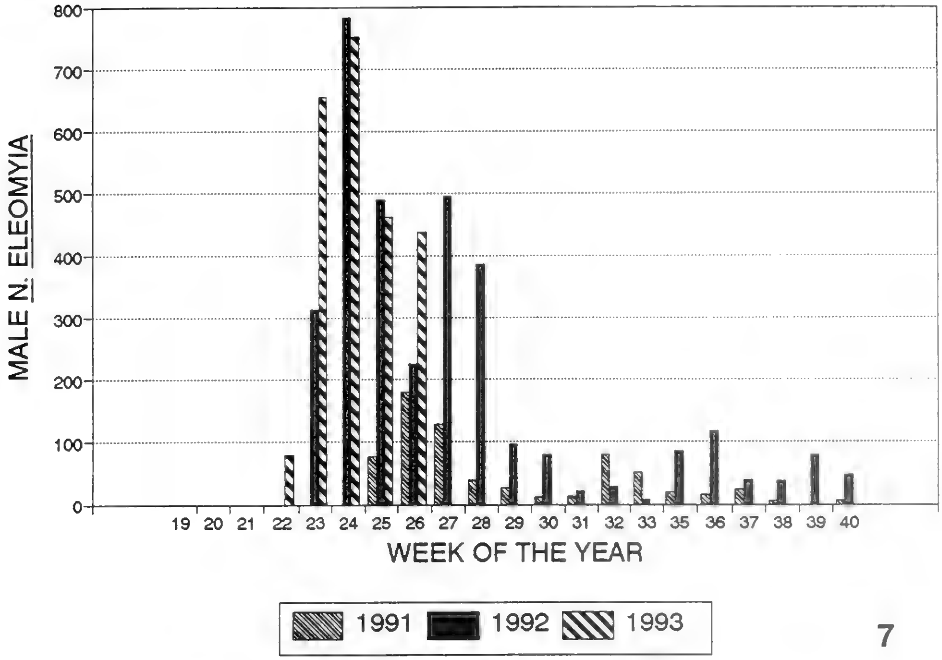
within days of the same date on all three years, VI-19-91, VI-17-92, and VI-16-93.

Pan trapping in the Horning Road marsh.—Only 408 adults (38.2% males) of five species of *Notiphila* were taken in the Horning Rd. marsh during the year-long survey (Table 1). The relative abundances of the five species were somewhat different than those obtained in the larger marsh. *Notiphila eleomyia* and *N. kentensis* accounted for 51.9% and 20.5%, respectively, of the adults trapped. However, the third most abundant species was *N. pauroura,* accounting for 13.5%, followed by *N. nudipes* (11.5%) and *N. olivacea* (2.6%).

Emergence traps.—Somewhat surprisingly, only nine males and 15 females of three species, *N. eleomyia* (5), *N. nudipes* (3), and *N. bella* (1), were collected in the emergence traps. All appeared between VI-17 and VI-29-92. Most of the adults were taken at site 1, and none was taken in the trap at site 4.

Core sampling.—Twenty *Notiphila* larvae, all third instar, were extracted from the core samples of mud that were taken intermittently in the marshes (Table 2). No larvae where reared to the adult stage, so species identification was not possible.

Rhizome and root sampling.—A total of 229 larvae and 91 puparia were collected from samples of *Nuphar* rhizomes and roots (Table 3). All of the larvae were found during the late fall and early spring months in mud adhering to the rhizomes and roots. In contrast, all puparia were firmly affixed to the primary roots of the rhizomes and roots (Fig. 21) and were found only during late



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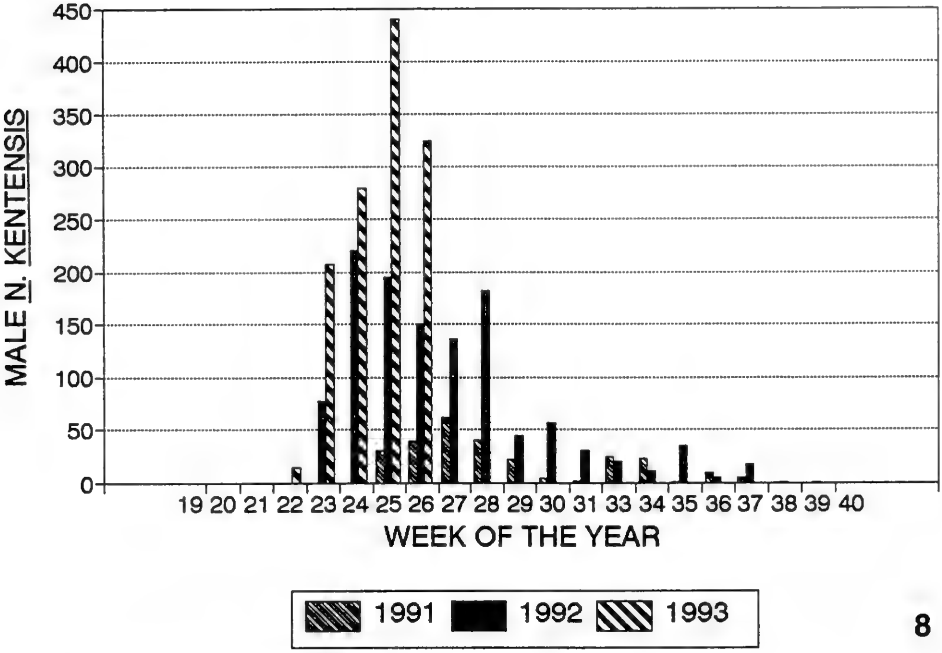

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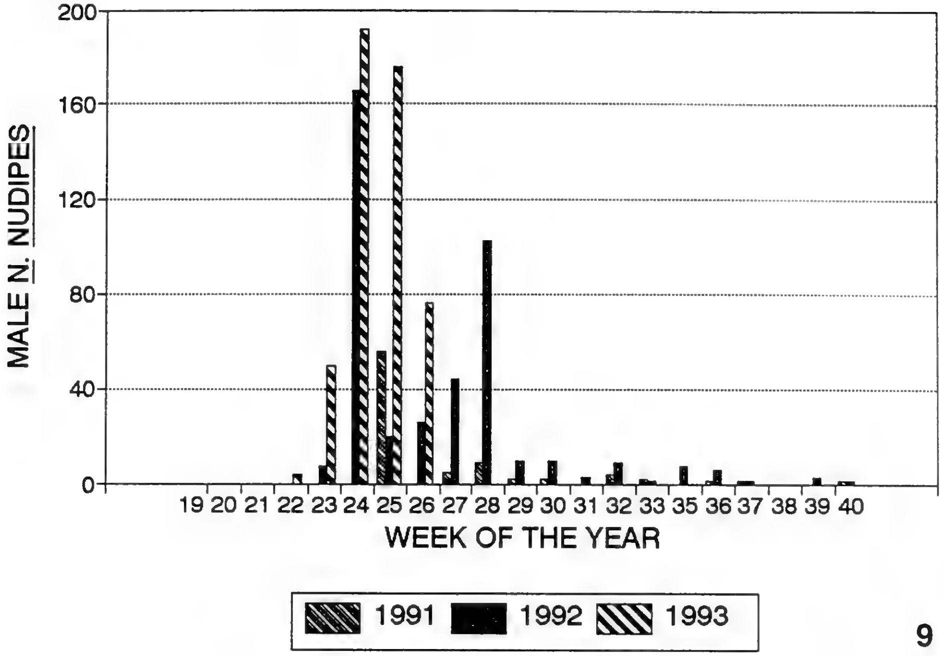
Figs. 7–8. 7, Seasonal distribution of *Notiphila eleomyia* in the Route 43 marsh. 8, Seasonal distribution of *N. kentensis* in Route 43 marsh.



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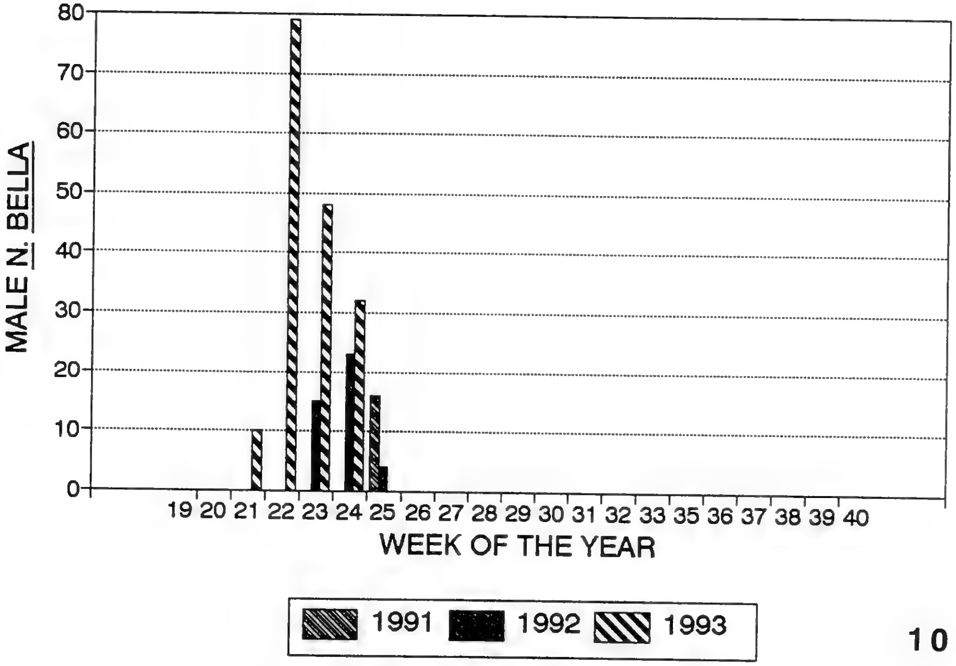

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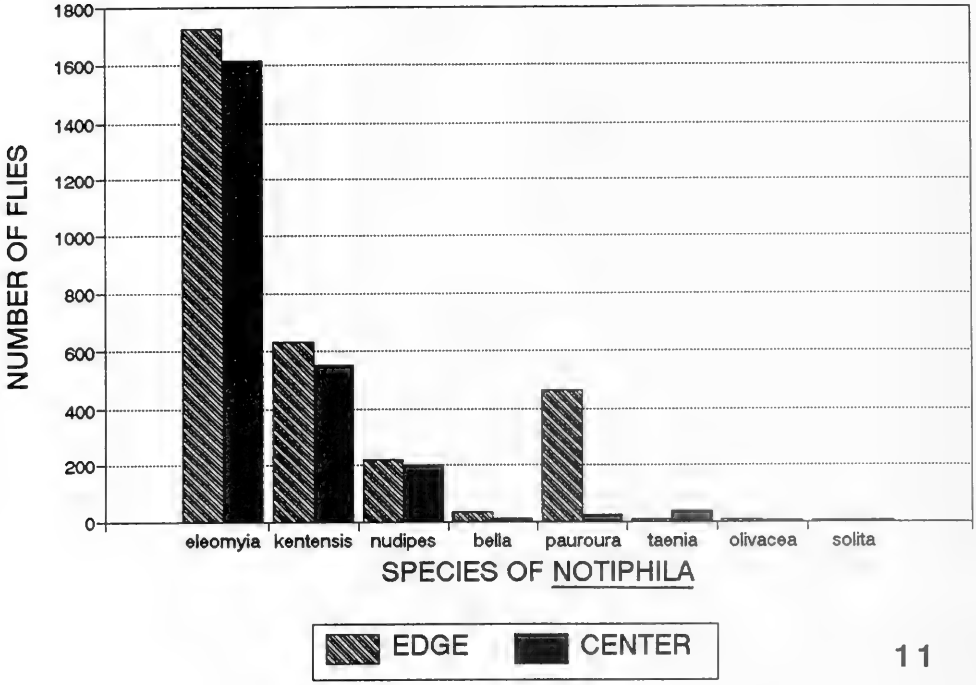
Figs. 9–10. 9, Seasonal distribution of adult *Notiphila nudipes* in the Route 43 marsh. 10, Seasonal distribution of adult *Notiphila bella* in the Route 43 marsh.



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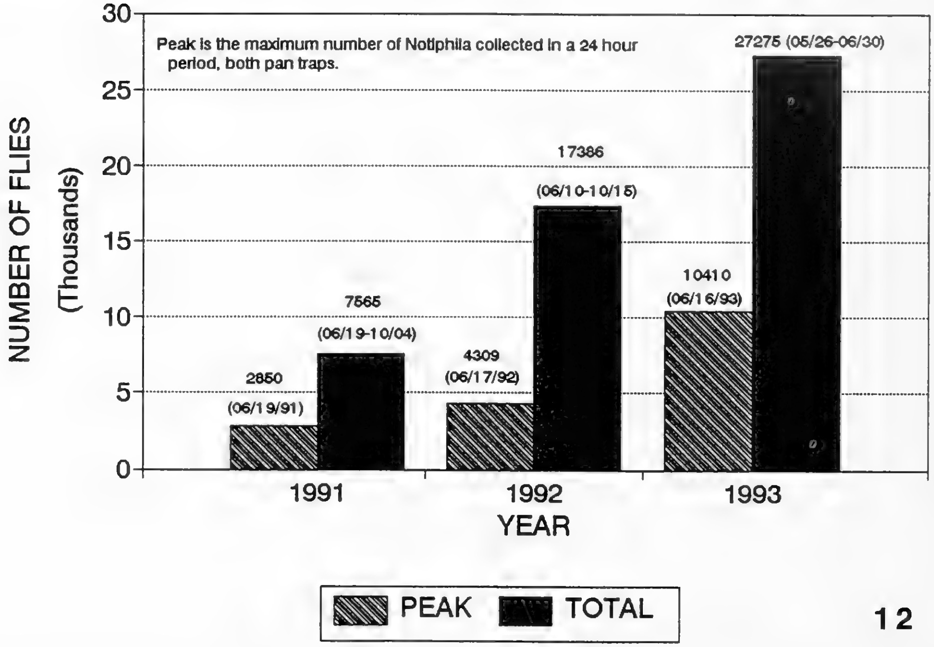

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Figs. 11–12. 11, Spatial distribution of adult *Notiphila* in the Route 43 marsh during 1992. 12, Total number of *Notiphila* collected in the Route 43 marsh between 1991 and 1993.

Table 2. Larvae collected in core samples taken at the Route 43 marsh in Portage County, Ohio.

Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
09/20/91	9	*	*	*	*	*
02/18/92	3	0	0	0	0	0
09/25/92	2	0	1	0	0	0
10/08/92	1	0	1	0	0	0
04/06/93	2	0	0	0	1	0
Totals	17	0	2	0	1	0

* Not sampled.

Table 3. Number of *Notiphila* taken from roots of *Nuphar luteum* at the Route 43 marsh.

Date		Site 2	Site 4	Site 6
09/20/91	Larvae	5	*	*
	Puparia	0	*	*
05/28/92	Larvae	1	1	1
	Puparia	49	0	14
06/03/92	Larvae	0	*	*
	Puparia	21	*	*
04/06/93	Larvae	122	57	4
	Puparia	0	0	0
04/27/93	Larvae	26	6	13
	Puparia	3	0	0

* Not sampled.

May and early June. Frequently, several puparia were attached to the same primary root, and there appeared to be a preference for the smaller roots located near the apical end of the rhizome. Some 20 puparia found on 10 roots of a single rhizome were all on roots that measured from 1.1 to 2.8 mm in diameter at the point where the root attached to the rhizome.

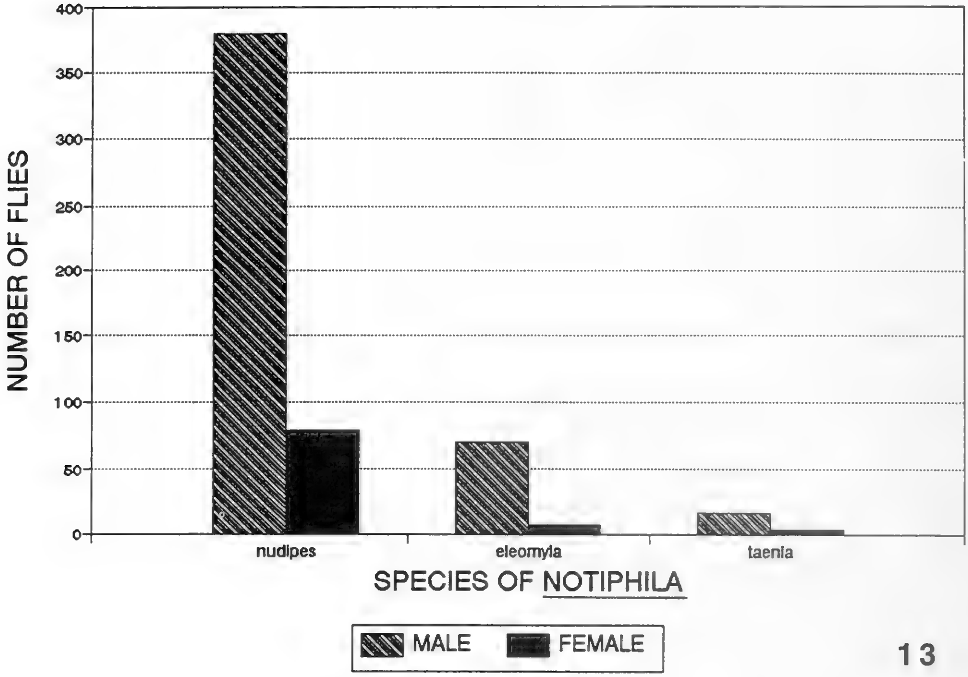
ADULT BEHAVIOR

The adult behavior of the species studied in this investigation resembled that described for other species of *Notiphila* by Busacca and Foote (1978), Deonier et al. (1978), Simpson (1976) and Van der Velde and Brock (1980). Adults spent most of their time walking over the surfaces of the *Nuphar* leaves and stems. They flew only a few centimeters when disturbed. While on the leaves, adults frequently paused to "taste" the surface, feeding on a microflora or absorbing the abundant honeydew deposited by a large leafhopper (Homoptera: Delphacidae) population. They were also observed to feed on bird droppings.

Courtship and Mating Behavior.—The flower buds, expanded flowers, and fruits of *Nuphar* were sites of a courtship aggregation of males that resembled lekking (Höglund and Alatalo, 1995). Large numbers of males, usually of a single species, distributed themselves rather evenly over the flower (Fig. 13) or bud (Fig. 14). They faced downward towards the water surface and held their wings out approximately 30 degrees from the centerline of the body, forming a v-shape (Fig. 15). Males constantly jostled each other and maintained a fairly uniform spacing. Whenever an interloper landed on the flower, it was quickly pounced upon by the nearby flies. If the newcomer was a male, he joined the group after a bit of shuffling to accommodate him. If the visitor was a female, there was a struggle among the males for her attention until one individual was able to copulate with her. Once the female was mounted, the other males resumed their positions on the flower head and ignored the mating pair. Occasionally, a male attempted to disrupt the mating pair, but these efforts were usually unsuccessful.

Males were particularly attracted to flowers that possessed numerous *Notiphila* eggs. Of male aggregations on 29 flowers, 16 flower buds, and two fruits that were examined, all but one possessed eggs (Fig. 16). On one occasion, an aggregation of six males of *N. eleomyia* was observed on a leaf that supported 775 eggs (Fig. 17).

Aggregations were observed in *N. eleomyia* and *N. nudipes* but not in *N. bella, N. kentensis,* or *N. taenia.* Mating behavior in those 3 species remains unknown. Male aggregations of *N. nudipes* typically were on the expanded flowers (418 of 488 males collected on flowers were of this species), whereas males of *N. eleomyia* were more commonly found on the buds (119 of 223



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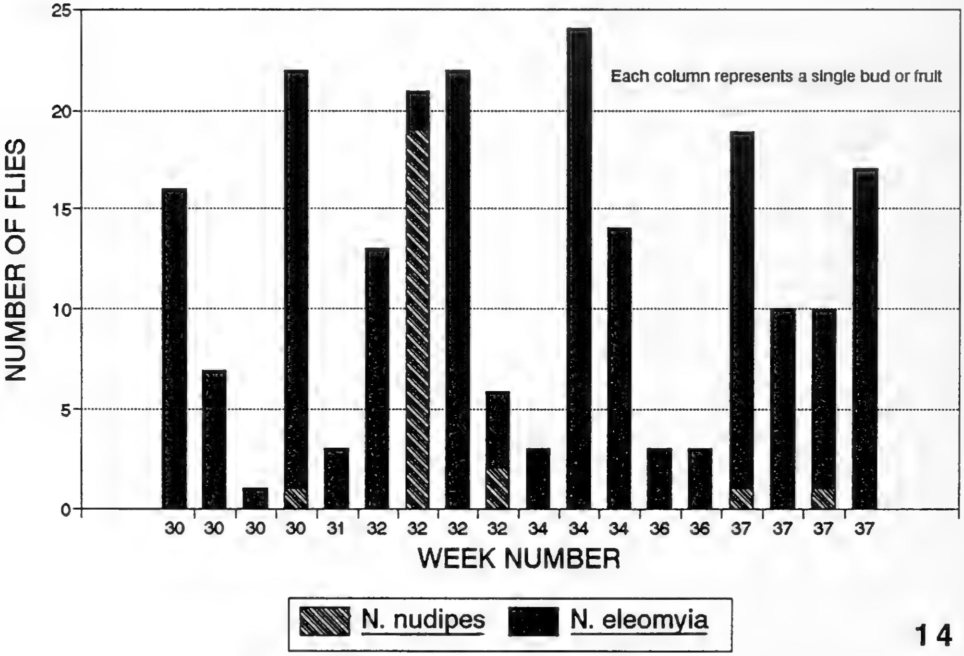

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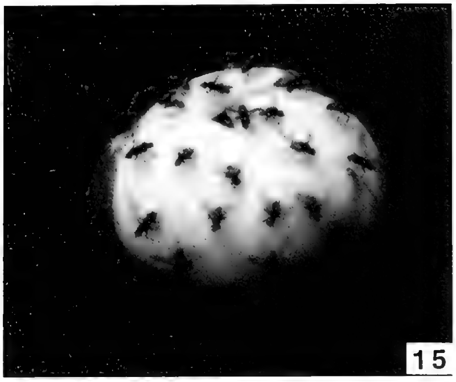
Figs. 13–14. 13, Total number of *Notiphila* on expanded flowers of *Nuphar luteum* at the Route 43 marsh during 1992. 14, Number of males of *Notiphila* on flower buds of *Nuphar luteum* at the Route 43 marsh during 1992.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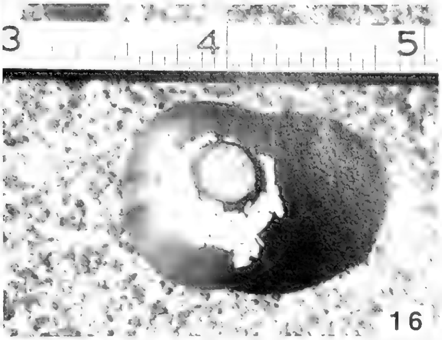
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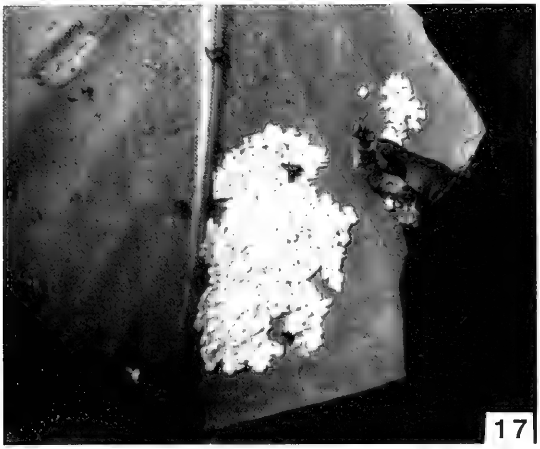
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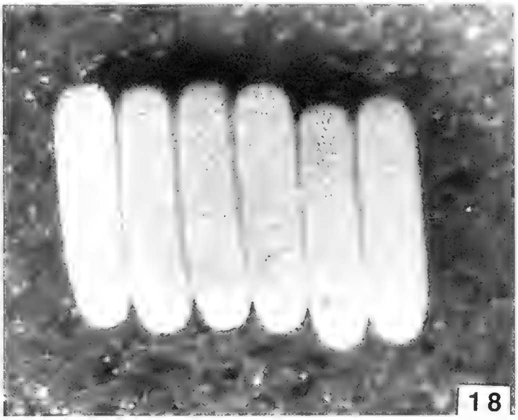
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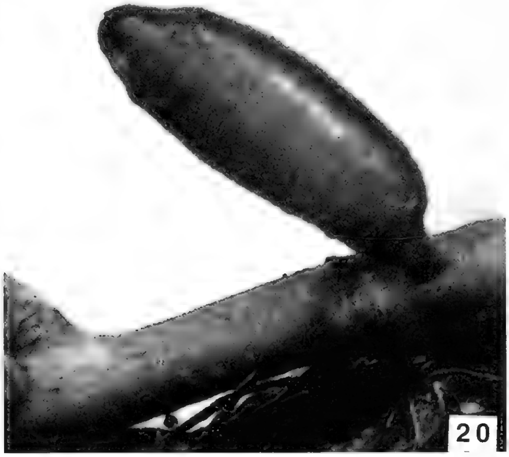
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Figs. 15–20. 15, Aggregation of males of *Notiphila nudipes* on flowers of *Nuphar luteum.* 16, Eggs of *Notiphila* sp. on the underside of flower bud of *Nuphar luteum.* 17, Eggs of *Notiphila eleomyia* on the underside of a leaf of *Nuphar luteum.* 18, Close-up of *Notiphila* eleomyia. 19, Spiracular spine of larva of *Notiphila* sp. 20, Puparium of *Notiphila* sp. attached to primary root of *Nuphar.*

males collected on buds were of this species).

Mating.—Mating activity was observed in two pairs of adults of *N. eleomyia* on two flower buds that also supported several other males. Each flower bud also had 60–90 *Notiphila* eggs. In the first pair, mating lasted for six minutes. After initial copulation was completed, the male continued to ride the female for another six and a half minutes and then re-initiated copulation, remaining in copula for an additional two minutes. The female terminated copulation by pushing at the male with her hind legs. She remained on the bud, whereas the male flew away. In the second pair, copulation lasted four and a half minutes. The male then continued to ride the female for another 12 minutes before decamping.

Copulating females frequently moved about on the surface of the leaves while feeding on the accumulated honeydew. They commonly carried the male with them as they moved to the flowers for oviposition.

Oviposition.—The egg masses consisted of as few as six to a maximum of 615 eggs. Most of the egg masses were deposited primarily on the reproductive parts of *Nuphar,* although a few were found on leaves. Less than one percent of 300 leaves examined weekly along the transsect possessed egg clusters, whereas over 96% of the examined flowers supported egg masses (Table 4). In large egg masses on buds, flowers, and fruits, eggs were deposited on all surfaces of these reproductive parts and frequently consisted of two or three layers. In contrast, masses deposited on leaves were always on the lower side of the leaf and usually consisted of only one layer of eggs.

The number of eggs laid per female during any one time interval varied from species to species. Females seemingly matured and deposited a full complement of eggs at one time. Two field-collected females of *N. eleomyia* deposited clusters of 25 and 27 eggs, respectively, over 24 hours in a breeding jar, suggesting that 12–14 eggs were being released from each ovary. The ovaries of two dissected gravid females of *N. eleomyia* each consisted of 14 ovarioles. Each ovariole contained two fully formed eggs plus several others that were still undergoing oogenesis. In contrast, only six to eight ovarioles were found in each ovary of five dissected *N. nudipes.*

Table 4. Number of leaves and flowers of *Nuphar luteum* having eggs of *Notiphila.*

Week	Number of Leaves Examined	Number of Leaves With Eggs	Number of Flowers Examined	Number of Flowers With Eggs
24	300	0	*	*
25	300	0	*	*
26	300	6	*	*
27	300	1	*	*
28	300	3	18	18
29	300	0	6	6
30	300	1	10	9
31	*	*	10	8
32	*	*	10	10
33	*	*	10	10
34	*	*	10	10
35	*	*	8	8
36	*	*	7	6

* Not sampled.

Eggs of both *N. eleomyia* and *N. nudipes* are white in color, show distinct texturing on the upper surface (Fig. 18), and are smooth on their ventral side. A distinct line separates the two areas. The textured dorsal surface of the egg may serve as a plastron that allows respiration to continue even when eggs are immersed in water (Hinton 1953, 1968; Deonier et al., 1978). Van der Weld and Brock (1980) demonstrated that eggs of *N. brunnipes* Robineau-Desvoidy, an European species, developed normally and hatched when submerged in well-aerated water. The incubation period for eggs of *N. eleomyia* and *N. nudipes* was three to four days. A longitudinal line of weakness at the micropylar end of the egg split open at the time of hatching, allowing the larva to emerge.

The only observed enemy of the eggs was an undetermined species of Trichogrammatidae (Hymenoptera). Every egg of a cluster of 300 located on a *Nuphar* leaf was parasitized by this wasp.

LARVAL BEHAVIOR

Newly hatched larvae dropped from the egg masses and moved into the anaerobic sediments surrounding the roots of *Nuphar.* They fed on these sediments during the summer and fall, usually attaining the third instar before overwintering. Feeding resumed the following spring, and larvae attached themselves to the *Nuphar* roots in May (Fig. 19). The puparia were firmly affixed to the roots (Figs. 20, 21) throughout the pupal period, which lasted 14–25 days. *Notiphila bella* appeared to be univoltine, and was the first species to emerge as adults (third week of May). No adults of this species were collected after the third week of June. The remaining three species may be multivoltine, although the data are inconclusive. One possible indication of a multivoltine habit was the discovery of eight adults of *N. eleomyia* on October 8, 1992, whose ptilina were still exposed. All of these species emerged later (early June) than *N. bella* and were present in the marshes over a longer period, with adults of three species being encountered as late as early October. *Notiphila* populations peaked in late June and steadily declined as summer progressed.

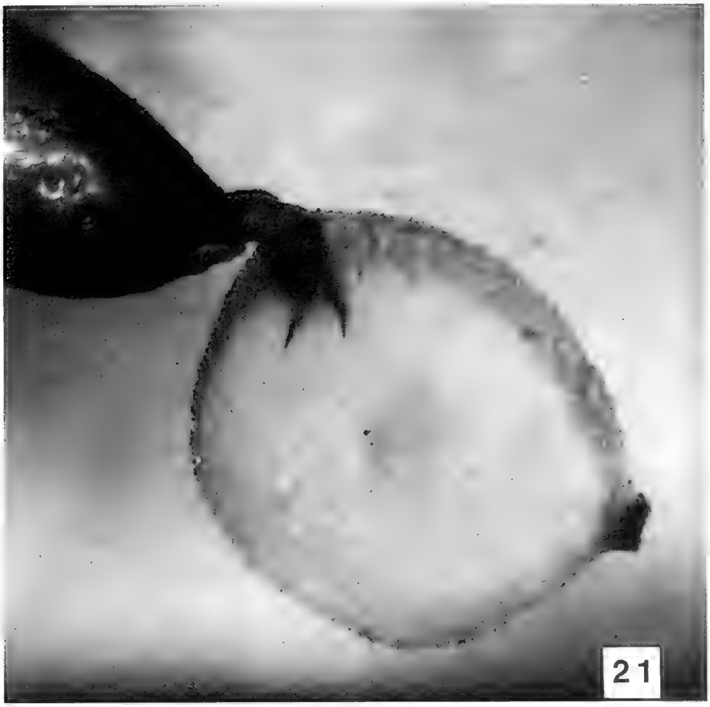
DISCUSSION

There is little evidence that competition was an important factor among the five species of *Notiphila* that dominated the *Nuphar* guild, and resource partitioning was not overly apparent. One possible example of partitioning was the fact that *N. bella* was univoltine and emerged earlier than the other four species. The two species that formed male aggregations preferred different sites, as males of *N. nudipes* formed aggregations on open flowers, whereas those of *N. eleomyia* aggregated on flower buds. Larvae of all five species co-occurred within the anaerobic sediments and apparently fed on the organic detritus. They all attached themselves to roots of *Nuphar* before forming puparia.

The huge number of adults obtained in the pan traps (Fig. 22) strongly suggests that the various species of *Notiphila* comprising the *Nuphar*-associated guild experience ecological release and thus can attain very large populations. We encountered very few other insect larvae in the anaerobic sediments that could be competing for the same food resource with *Notiphila,* and predators were rarely encountered.

There is a strong correlation of the life cycle of the *Nuphar*-associated species of *Notiphila* with the time of maximum oxygen richness in the roots of the water lily. Movement of oxygen from the leaves to the stems and into the roots involves diffusion and mass transport of gases driven by photosynthesis occurring in the aerial portions of *Nuphar.* Oxygenation of the rhizome and associated roots is particularly apparent in the spring when newly formed leaves are beginning to appear (Dacey 1981). This ensures that the developing pupae have access to a rich source of oxygen at a time when demand is particularly high.

An interesting question concerning *Notiphila* is why the genus is so speciose? It is the second largest genus of Ephydridae in North America (53 spp.) being exceeded only by the phytophagous genus *Hydrellia* (60 spp.) (Wirth et al. 1987, Mathis and Zatwarnicki 1995). There is a general feeling among systematists that genera comprised of plant-feeding taxa are more speciose than genera composed of predators or scavengers (Mitter et al. 1988). Speciation in phytophagous insects apparently occurred as populations shifted to new host plants and gradually adapted to the particular set of environmental conditions presented by the different host taxa. The large genus *Hydrellia* is composed of leaf-mining and stem-boring species and thus follows the expected pattern. On the other hand, species of *Notiphila* are basically detritivores, feeding on anaerobic sediments in wetland habitats. What could have driven such prolific



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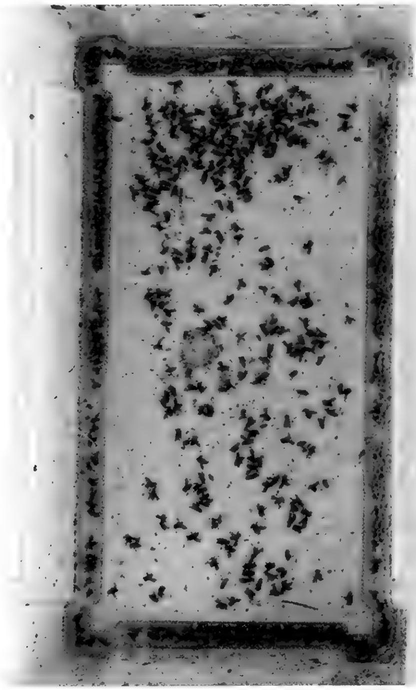

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Figs. 21–22. 21, Respiratory spines of puparium of *Notiphila* sp. embedded in primary root of *Nuphar luteum.* 22, Adults of *Notiphila* in detergent in water pan trap collected over a 24-hour period.

Table 5. Known "host plants" of North American species of *Notiphila.*

Notiphila Species	Host Plant Genus	Source
The *adusta* group		
N. bella	*Nuphar*	This paper
N. kentensis	*Nuphar*	This paper
N. mathisi	*Nuphar*	Huryn 1984
N. nudipes	*Nuphar*	This paper
N. taenia	*Nuphar*	This paper
N. theonae	*Nuphar*	Huryn 1987
The *loewi* group		
N. carinata	*Justicia*	Deonier et al. 1978
N. eleomyia	*Nuphar*	This paper
N. loewi	*Potamogeton*	Berg 1950
N. pauroura	*Nuphar*	This paper
N. poliosoma	*Potamogeton*	Mathis 1979
N. shewelli	*Nuphar*	Mathis 1979
N. solita	*Typha*	Busacca & Foote 1978
The *pulchrifrons* group		
N. scoliochaeta	*Carex*	Mathis 1979
The *bispinosa* group		
N. bispinosa	*Spartina*	Foote, pers. obs.
N. furcata	*Spartina*	Foote, pers. obs.
The *scalaris* group		
N. aenigma	*Typha*	Busacca & Foote 1978
N. decoris	*Glyceria*	Foote, pers. obs.
N. macrochaeta	"Grasses"	Mathis 1979
N. olivacea	*Nuphar*	This paper
N. quadrisetosa	*Agrostis*	Mathis 1979
N. scalaris	*Leersia*	Foote, pers. obs.

speciation in this genus? We suggest that speciation occurred as populations within species of *Notiphila* adapted to different wetland plants as sources of oxygen. All species of *Notiphila,* except for those of the *caudata* group of the subgenus *Dichaeta,* are thought to obtain their oxygen from aerenchymatous tissue in the roots of wetland plants. As Table 5 shows, 22 species of *Notiphila* occurring in North America have known "host plants", although the plant associations of 31 species are still unknown. Generalizations about suggested plant-insect relationships within the genus thus must be very tentative. The plants utilized by the five species of the *avia* group are completely unknown, and only one of the three species comprising the *pulchrifrons* group has a suspected host plant. One generalization solidly supported by evidence is that species of Monocotyledonae are preferred over species of Dicotylondeae. Only *N. carinata,* has been reported from a species of dicot (*Justicia americana* (L.) Vahl), whereas 21 species have been associated with monocots. Another well-supported generalization is that the genus *Nuphar* is heavily used by *Notiphila* larvae. At least 10 species of three different species groups representing both subgenera are known, or suspected, to attach their puparia to roots of species of yellow water lily. The *adusta* species group may be restricted to *Nuphar,* as six of its 11 species are considered to be affiliated with yellow water lilies. Finally, species of the *furcata* and *scalaris* species groups seem to show a preference for species of grasses, as six of the 19 species in those groups are known to utilize Gramineae. An interesting divergence from the typical *Notiphila* feeding pattern is possessed by species of the *caudata* group, as larvae of the only reared species, *N. dichaeta,* feed on surface sediments and do not possess spiracular spines.

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DESCRIPTIONS OF FOUR NEW SPECIES OF CYNIPID GALL WASPS OF THE GENUS *NEUROTERUS* HARTIG (HYMENOPTERA: CYNIPIDAE) WITH REDESCRIPTIONS OF SOME KNOWN SPECIES FROM THE EASTERN UNITED STATES

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Abstract.—Four new species of cynipid gall wasps of the genus *Neuroterus* Hartig from the eastern United States are described: ***N. archboldi*** Melika and Abrahamson, ***N. chapmanii*** Melika and Abrahamson, ***N. christi*** Melika and Abrahamson, and ***N. weldi*** Melika and Abrahamson. Four common eastern United States species of *Neuroterus* are redescribed and four species are newly synonymized: *N. quercusbatatus* (Fitch) (*Cynips noxiosus* Bassett, **new synonymy**); *N. quercusirregularis* (Osten Sacken) (*Cynips quercusmajalis* Bassett, **new synonymy**); *N. quercusminutissimus* (Ashmead); and *N. quercusverrucarum* (Osten Sacken) (*Cynips flocossus* Bassett and *Neuroterus exiguissimus* Bassett, **new synonymies**).

Key Words: Cynipidae, gall wasps, Neuroterus, taxonomy, morphology, distribution, biology

Neuroterus Hartig, 1840, is a holarctic genus with numerous representatives in the Old World (Eurasia) and North America. Burks (1979) listed 52 species for America north of Mexico, 33 of which are restricted to the eastern United States. This genus is easily distinguished from other genera of oak gall-inducing cynipids by the absence of a scutoscutellar suture; usually smooth and thin body with a delicate coriaceous or alutaceous sculpture on the thorax; radial cell of fore wing long and narrow; and usual absence of notauli. All known species of this genus cause galls only on oaks of the subgenus *Lepidobalanus,* except *N. chrysolepis* Lyon which is associated with *Quercus chrysolepis* Liebm. of the subgenus *Protobalanus* (Lyon 1984). The structure of *Neuroterus* galls is usually more primitive than those of other genera, and they lack highly specialized tissues and layers. Furthermore, the walls of the larval cell usually are incorporated into the outer tissues of the gall and do not separate from the gall's wall when the insect matures.

Numerous species of *Neuroterus* were described from the eastern United States before the end of the previous century, and very often the only differences among the described species were the host oaks from which the galls were collected. Furthermore, the descriptions of the species are incomplete and insufficient. Thus, eight common species of *Neuroterus* known from the eastern United States are very difficult to identify, either on the basis of the galls or adults. These are *N. quercusirregularis* (Osten Sacken) and *N. quercusmajalis* (Bassett); *N. quercusbatatus* (Fitch) and *N. noxiosus* (Bassett); and *N. exiguissimus* Bassett, *N. flocossus* (Bassett), *N. quercusminutissimus* (Ashmead), and *N. quercusverrucarum* (Osten Sacken). The descriptions and diagnostic characters for separation of these species given by various authors (Ashmead 1885a, 1885b, 1887; Bassett 1864, 1881, 1900; Fitch 1859; Osten Sacken 1861, 1865) hardly allow discrimination of all species. Examination of types of these species indicates that some are synonyms. Kinsey (1923), in his revision of *Neuroterus,* treated *N. exiguissimus, N. flocossus,* and *N. minutissimus* as varieties of *N. quercusverrucarum*; *N. noxiosus* as a variety of *N. quercusbatatus,* and *N. quercusmajalis* as a variety of *N. quercusirregularis.* He was correct in splitting these species, except *N. quercusminutissimus* which, in our opinion, is a distinct species. However, Kinsey's synonymies did not follow the International Code of Zoological Nomenclature. Furthermore, his use of "variety" and "form" makes his classification confusing and difficult to use. Nevertheless, we give credit to Kinsey for recognizing the similarities among the above-listed species. Thus, redescriptions, diagnostic characters, taxonomic comments, and data on distribution and biology for these eight species are given.

We follow the current terminology for morphological structures (Eady and Quinlan 1963, Fergusson 1995, Gibson 1985, Menke 1993, Ritchie and Peters 1981, Ronquist and Nordlander 1989). The term "thorax" used here includes the propodeum and thus is equivalent to the "mesosoma" or "mesosoma+metasoma" of the American literature. Abbreviations for fore wing venation follow Ronquist and Nordlander (1989). Measurements and abbreviations used here include: F1–F12, first and subsequent flagellomeres; POL (post-ocellar distance), the distance between the inner margins of the posterior ocelli; and OOL (odellar-ocular distance), the distance from the outer edge of a posterior ocellus to the inner margin of the compound eye.

Depositories for specimens are the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM) and the American Museum of Natural History, New York, New York (AMNH).

Neuroterus archboldi Melika and Abrahamson, NEW SPECIES
(Figs. 1-6)

Diagnosis.—No *Neuroterus* galls known from the United States have galls similar to *N. archboldi* (Figs. 5, 6).

Description.—Bisexual female: Dark brown to black, with frons, clypeus and mouthparts of some specimens yellow brown. Head from above about twice as wide as long, slightly broader than thorax, gena not broadened behind eye (Fig. 1); interocular space punctate, black, broader than high; vertex finely coriaceous; distance between antennal sockets shorter than distance between socket and inner margin of eye; no distinct carina between antennal sockets; frons punctate, broader than high, yellow brown or yellow, with few scattered pale setae; clypeus yellow, rounded, its apex distinctly emarginate; anterior tentorial pits deep; malar space short, with faint malar groove. Antenna 13-segmented, yellow, as long as head and thorax together, with pale dense setae, basal 4 segments lighter than rest; F1 slightly shorter than pedicel and scape together, twice as long as F2 (Fig. 2). Scutum rounded, only very slightly broader than long, smooth and shining, very finely coriaceous, without trace of notauli, anterior parallel, and parapsidal lines; posterior margin slightly emarginate on both sides of transverse groove at base of scutellum; groove deep, smooth. Scutellum slightly longer than broad, smooth, shining, finely coriaceous with very few scattered short, pale setae. Pronotum, mesepisternum, and sides of propodeum finely punctate, lighter than scutum and scutellum. Medial part of propodeum uniformly sculptured, without carinae. Fore wing 1.5 mm long, uniformly and densely hairy, longer than body, with cilia on margins, with light smoky spot on M at junction of Cu_1; veins thick, brown, Rs+M reaches M; areolet distinct, triangularly rounded (Fig. 4). Legs, including coxae pale yellow, semitranslucent, pretarsus dark brown to black; claws without tooth. Gaster darkish brown, smooth, in dry shrunken specimens, nearly same height and length; tip of ovipositor slightly curved, ventral spine of hypopygium visible laterally, with short sparse pale setae. Length, 1.3-1.4 mm. Male: Color lighter than female, except for head. Eye slightly larger than in female, interocular space black, punctate, with duller sculpture than finely coriaceous vertex. Anterior tentorial pits indistinct (unusual for males of species that induce integral leaf galls; usually males with very deep tentorial pits). Antenna 14-segmented, F1 longer than pedicel and scape together, only very slightly curved and extended in posterior part (Fig. 3). Fore wing slightly darker than in female, larger, length 2.0 mm. Petiole very distinct, long. Length, 1.3 mm.

Types.—Holotype ♀; allotype ♂ from Archbold Biological Station, Lake Placid, Highlands Co., Florida, on *Q. chapmanii* Sarg., 28 March 1995, emerged 30 March 1995. Also 25 ♀ and 4 ♂ paratypes. Holotype, allotype, 4 ♀ paratype, 1 ♂ paratype, and galls in the USNM; 5 ♀ paratypes, 1 ♂ paratype and galls in AMNH; 15 ♀ paratype, 2 ♂ paratypes, and galls in G. Melika private collection.

Etymology.—Named in honor of Mr. Richard Archbold, founder of the Archbold Biological Station.

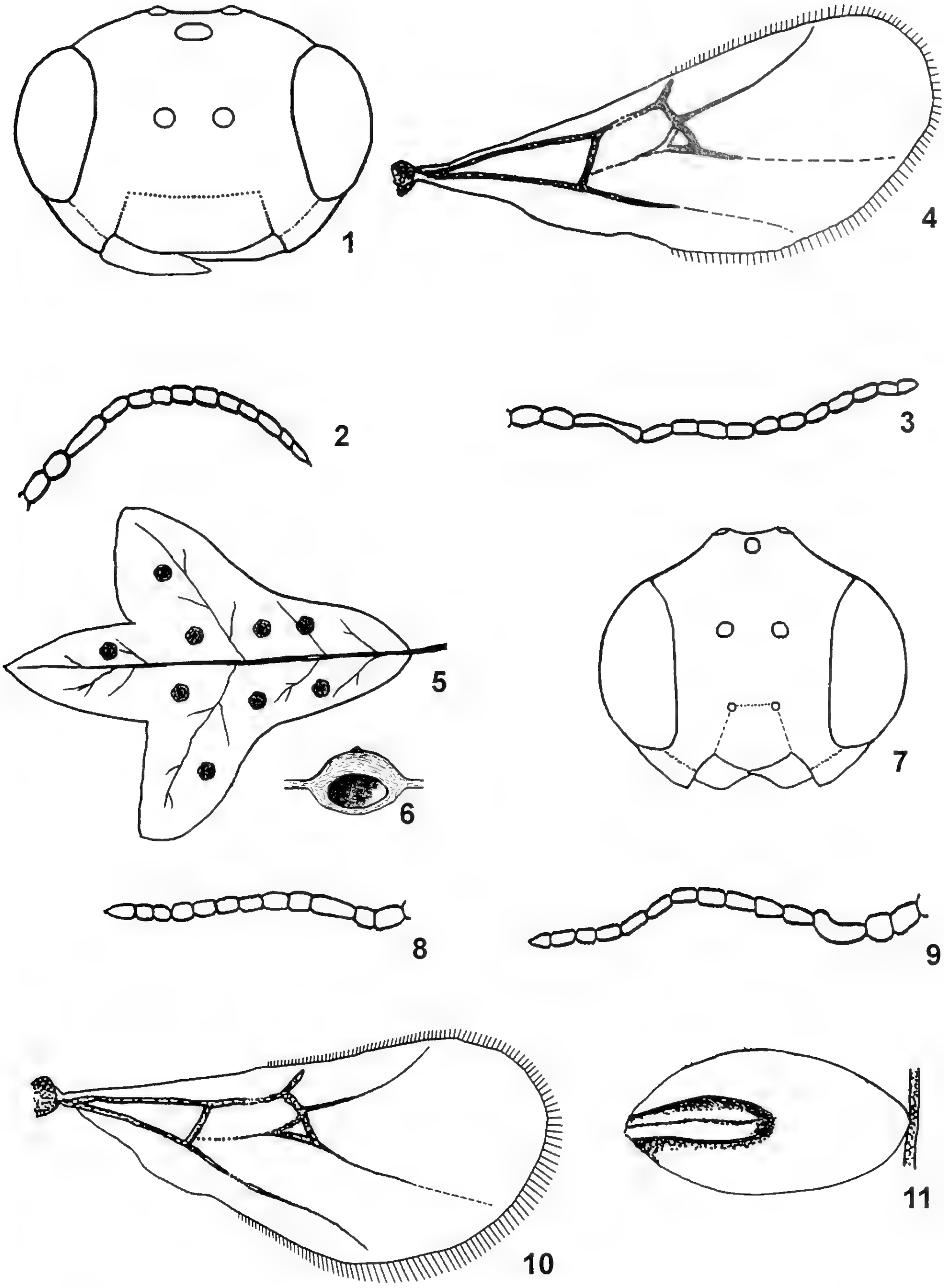
Distribution.—Florida (Archbold Biological Station, Lake Wales Ridge, Highlands Co.; Jonathan Dickinson State Park, Martin Co.).

Biology.—Only the bisexual generation is known, and the only known host for *N. archboldi* is *Quercus chapmanii.* This species induces blister-like parenchyma thickenings which are visible on both sides of the leaf but protrude more on the underside of the leaf. The gall is rounded, monothalamous, 1.5-2.0 mm in diameter, 1.0-1.5 mm high, green or whitish green, very slightly lighter than the leaf, and drier than the succulent polythalamous *N. quercusirregularis* galls (Figs. 5, 6). The larval cell is situated on the underside of the leaf, not separated from the outer layers of the gall. There are 18 to 25 or more galls per leaf. After adults emerge, the galls shrink and wrinkle and dry out and drop. Consequently, rounded holes remain in the leaf. We observed these galls actively growing for the first time on 9 March 1995. Adults emerged the second and third week of March into April. They were very common leaf galls on *Q. chapmanii* at the Archbold Biological Station. Simultaneous with this species, *N. quercusirregularis* galls could develop on the same leaf, but they are easily distinguishable from those of the former on the basis of galls. Our efforts to rear the alternate generation in cages containing emerged wasps on Chapman oaks were unsuccessful.

Neuroterus chapmanii Melika and Abrahamson, NEW SPECIES

(Figs. 7-11)

Diagnosis.—Three northeastern United States species of *Neuroterus* are similar to this new species on the basis of galls: *N. dubius* Bassett (egg-shaped capsule galls on the edge of leaves on aments (Kinsey 1923)); *N. exiguus* Bassett (galls a fleshy enlargement of the staminate axis (Weld 1959), or anther galls but very succulent and shrivel up and disappear after adults emerge (Bassett 1900)); and *N. pallidus* Bassett (galls are in clusters, usually on the end of catkins). Adults of all three mentioned species have character states that differ from *N. chapmanii. Neuroterus dubius* has notauli and a coriaceous scutellum while the other three species lack notauli and have a smooth, shiny scutellum. *Neuroterus exiguus* has deep tentorial pits and the head in front view is nearly as high as broad, while in *N. chapmanii* and *N. pallidus* the head in front view is broader than high with shallow tentorial pits. In *N. chapmanii,* the head has a faint malar groove and the POL:OOL is as 3.5:2.0, while the



Figs. 1–11. 1–6, *Neuroterus archboldi.* 1, Female head, front view. 2, Antenna of female. 3, Antenna of male. 4, Fore wing of female. 5, Typical arrangement of galls on leaf (1×). 6, Saggital section of gall showing larval chamber (10×). 7–11, *N. chapmanii.* 7, Female head, front view. 8, Antenna of female. 9, Antenna of male. 10, Fore wing of female. 11, Shape of a single gall (30×).

head of *N. pallidus* lacks a malar groove and the POL:OOL is as 3.0:2.0.

Description.—Bisexual female: Dark brown to black. Head from above about twice as wide as long, broader than thorax, gena not broadened behind eye; interocular space coriaceous, broader than high; distance between antennal sockets same as distance between antennal socket and eye; frons coriaceous, broader than high, with densely and uniformly distributed short pale setae; clypeus rounded, its apex lighter, emarginate; malar space very short, with faint groove; mouthparts yellowish brown (Fig. 7). Antenna 12- or 13-segmented (some specimens with suture between 12th and 13th segments indistinct), pale yellow, with short pale dense setae; longer than head and thorax together; F1 as long as pedicel and scape together, two times longer than F2 (Fig. 8). Scutum rounded, slightly longer than broad, smooth and shiny, very finely coriaceous, without trace of notauli, anterior parallel and parapsidal lines. In specimens with shrunken and collapsed thorax, median line and anterior parallel lines appear as dark lines. Posterior margin of scutum slightly emarginate on both sides from transverse groove at base of scutellum; groove large, smooth, incurved. Scutellum smooth, shining, very finely coriaceous with uniformly distributed short pale setae; slightly elongated. Pronotum and mesepisternum finely coriaceous, slightly lighter than scutum. Median part of propodeum uniformly coriaceous, some specimens with distinct median carina, some without carina. Fore wing longer than body, uniformly and densely pubescent, with cilia on margins, without smoky spots; veins thick, brown except paler Rs+M which reaches M; areolet triangular, large; length 1.5 mm (Fig. 10). Legs, including coxae, pale, semitranslucent; basal part of coxae and femora dark brown; pretarsus dark brown or black; claws without tooth. Gaster black, smooth, in dry specimens shrunken and wrinkled, higher than long; ovipositor straight, tip not hooked; ventral spine of hypopygium with short sparse pale setae, prominent, visible laterally. Length, 1.1 mm. Male: Color lighter than female. Eye considerably larger than in female, anterior tentorial pits deep; malar space shorter than in female; antenna 14-segmented, F1 longer than in female, very slightly curved and extended posteriorly (Fig. 9). In specimens with shrunken and collapsed thorax, median line and anterior parallel lines visible as dark lines. Fore wing longer than in female, 1.8 mm. Petiole long. Length, 1.2 mm.

Types.—Holotype ♀, allotype ♂, 17 ♀ and 7 ♂ paratypes. Archbold Biological Station, Lake Placid, Highlands Co., Florida, 6 March 1995, emerged 8 March 1995. Holotype, allotype, 4 ♀ and 2 ♂ paratypes and galls in the USNM; 4 ♀ and 2 ♂ paratypes and galls in AMNH; 9 ♀ and 3 ♂ paratypes and galls in G. Melika private collection.

Etymology.—Named from the host, *Quercus chapmanii.*

Distribution.—Florida (Archbold Biological Station, Lake Placid, Highlands Co.; Jonathan Dickinson State Park, Martin Co.).

Biology.—Only the bisexual generation is known. Galls are on catkins of *Quercus chapmanii,* are ovoid, thin walled, up to 1.5 mm long, and with a groove running from one side to the other across the upper surface thus resembling a closed purse (Fig. 11). The gall is covered with white pubescence, especially on the top, and is monothalamous. Galls are randomly scattered along the staminate axis and perpendicular to it. Sometimes two galls develop together. The galls are surrounded by anthers. As the gall and catkins mature, the color changes from green to pale brown. They remain on the catkins until emergence of the adult or longer, dropping along with the catkins. In Florida, on the Lake Wales Ridge, Chapman oak begins to flower the end of February to early March. We found the gall for the first time on 3 March 1995 when some of the galls had emergence holes, likely made by the gall-inducing wasps; also, pupae and adult wasps were cut from the galls on this date. The galls are found easily throughout the period of Chapman oak flowering. No inquilines were reared from these galls, but some parasitoids belonging to the Tetrastichinae (Hymenoptera: Eulophidae) emerged. This is a very common species on *Q. chapmanii* on the Lake Wales Ridge. Our efforts to rear the alternate unisexual generation were unsuccessful in spite of using cages containing emerged wasps on the branches of Chapman oaks.

Neuroterus christi **Melika and Abrahamson,** NEW SPECIES
(Figs. 12-16)

Diagnosis.—The female appears most similar to *N. quercusirregularis* but differs by the parallel inner margins of the eyes, shallow tentorial pits, smaller clypeus, and ratio of the third antennal segment to the first two together (1.7:1.0). In *N. quercusirregularis,* the eyes slightly converge inward at the posterior part of the frons; the anterior tentorial pits are deep, and the ratio of the third antennal segment to the first two segments combined is 1.3:1.0. The galls are also quite similar in appearance to those of *N. quercusirregularis,* but those of *N. christi* are strictly associated with *Q. geminata* and *Q. virginiana* Mill., not nearly so succulent, and usually of a regular cylindrical shape and not so irregularly shaped as those of *N. quercusirregularis.*

Description.—Bisexual female: Brown to dark brown. Head from above about 3 times wider than long, broader than thorax; gena not broadened behind eye, inner margins of eyes parallel; interocular space finely punctate, blackish brown to black, broader than high; POL to OOL as 1.7: 1.0; distance between antennal sockets smaller than between antennal socket and inner margin of eye; antennal apodemes distinctly depressed anteriorly; frons lighter than vertex and body, coriaceous, broader than high, with densely and uniformly distributed short pale setae, with median elevation in form of broad carina that widens posteriorly to width of clypeus and reaches antennal sockets; clypeus lighter than body and vertex, rounded, very slightly emarginated posteriorly; tentorial pits shallow; malar space short, with distinct malar groove (Fig. 12). Antenna 13-segmented, lighter than body, F1 slightly longer than pedicel and scape together and 2 times longer than F2 (Fig. 13). Scutum rounded, slightly longer than broad, smooth and shining, very finely coriaceous, without trace of notauli, anterior parallel, median, and parapsidal lines; however, possibly indicated by darker lines; with scattered very short pale setae; posteriorly emarginate on both sides from transverse groove at base of scutellum. Scutellum slightly longer than broad, smooth, shiny, very finely coriaceous, with very few scattered short pale setae; transverse groove anteriorly very distinct, deep, smooth, slightly incurved. Pronotum and mesepisternum shining, finely coriaceous. Medial part of propodeum finely punctate, without carinae, shiny and smooth on both sides. Fore wing hyaline, with cilia on margins, with smoky spot along M distally from areolet and with a very small darker smoky spot on junction of $M+Cu_1$ to M. Fore wing 1.9-2.0 mm long, slightly longer than body, areolet present, closed; Rs+M lighter than other veins (Fig. 15). Coxae and trochanters pale yellow, semitranslucent, sometimes tips of coxae brown; femora and tibia brown, tarsi yellowish brown, pretarsi blackish brown; claws without tooth. Gaster dark brown to black, smooth, higher than long; tip of ovipositor hooked; ventral spine of hypopygium prominent, visible laterally, with pale scattered setae. Length, 1.7 mm. Male: Color lighter than female. Eye larger than in female; antenna 14-segmented; F1 longer than pedicel and scape together, slightly curved and extended posteriorly (Fig. 14). Fore wing 2.2 mm long; body 1.6 mm long.

Types.—Holotype ♀, Bok Tower Gardens, Polk Co., Florida, on Q. geminata, 26 March 1995, emerged 26-27 March 1995. Allotype ♂, Lake Manatee State Recreation Area, Manatee Co., Florida, on *Q. geminata,* 9 April 1995, emerged 10 April 1995. 10 ♀ and 5 ♂ paratypes. Holotype, allotype, 3 ♀ and 2 ♂ paratypes and galls in the USNM; 3 ♀ and 1 ♂ paratypes and galls in AMNH; 4 ♀ and 2 ♂ paratypes and galls in G. Melika private collection.

Other material examined.—13 ♀ and 9 ♂, in addition to the two above-mentioned localities, from Buck Island Ranch, 13 km SW Brightly (Archbold Biological Station property), Highlands Co., Florida, on *Q. virginiana,* coll. 17 March 1995, emerged 26 March 1995.

Etymology.—Named in honor of Ms. Christy Raye Abrahamson, who provided continuous support during our seven months of research based at the Archbold Biological Station, and who first found this species.

Distribution.—Florida (Archbold Biological Station and 13 km SW Brighton, Buck Island Ranch, Highlands Co.; Lake Manatee Recreation Area, Manatee Co.; Bok Tower, Polk Co.; Eglin Air Force Base, Okaloosa and Walton cos.; Wakull Spring State Park, Wakulla Co.).

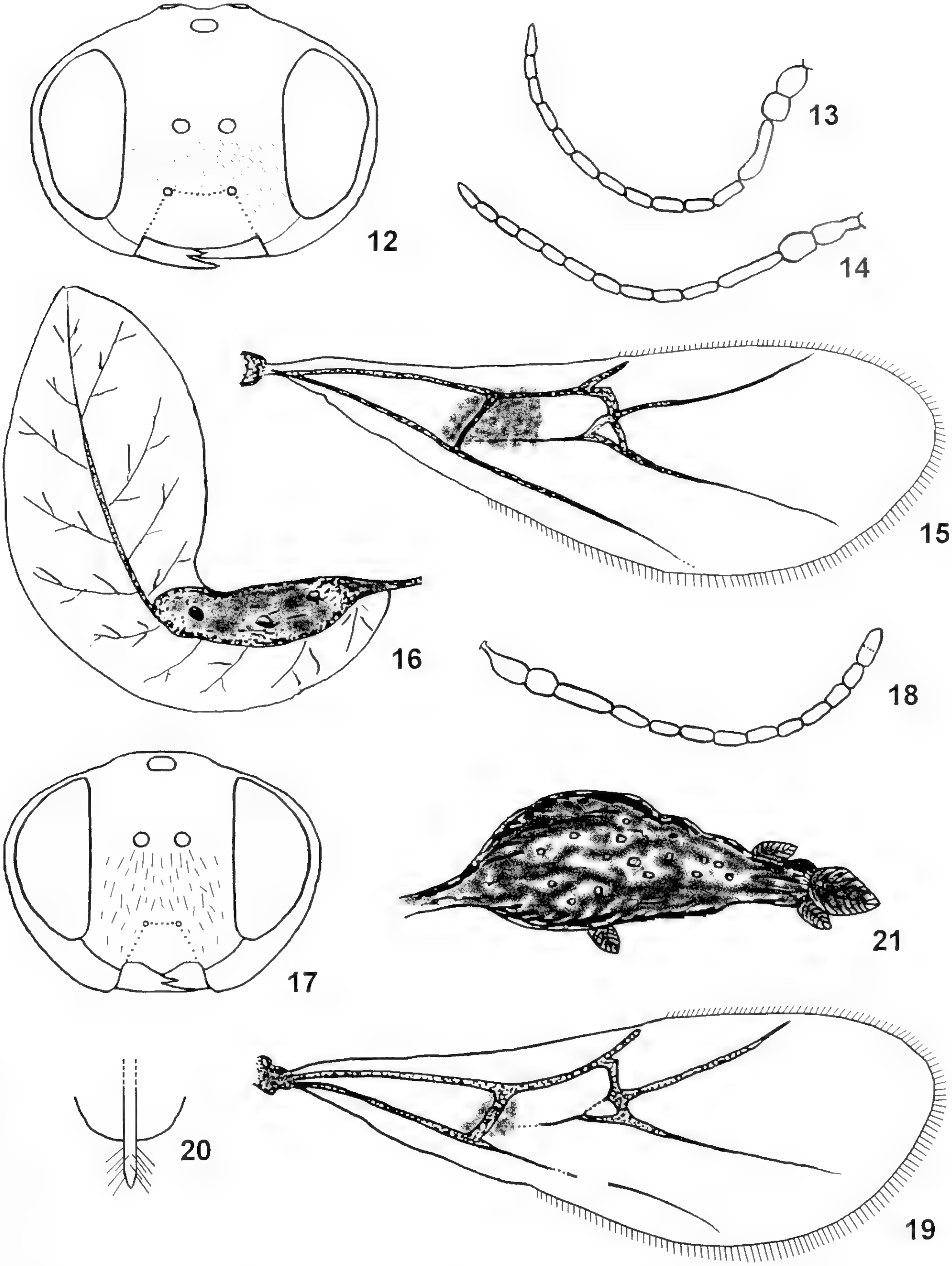
Biology.—Only the bisexual generation is known. The host oaks are *Quercus geminata* and *Q. virginiana.* The galls are leaf parenchyma thickenings, equally protruding on both sides of the leaf along one side of the main vein, green when young but turning brownish green when mature, polythalamous, generally with four to six larval cells per gall, about 12.0-15.0 mm long, 3.0-4.5 mm wide, and 3.0-4.5 mm high, and usually of a regular cylindrical form. The walls of the inner cells are whitish green and the surface of the gall is smooth, without hairs (Fig. 16). There are usually one or two galls per leaf. Adults usually emerge from the upper side. The first galls appear in mid-March, and the adults emerge the last week of May and beginning of June.

Neuroterus weldi Melika and Abrahamson, NEW SPECIES

(Figs. 17-21)

Diagnosis.—This species is related to *N. quercusbatatus* (Fitch), but the gena are broadened behind the eyes; a distinct carina on the vertex reaches between the antennal sockets; the area around the antennal sockets is depressed; the medial carina on the frons is distinct only in the lower half; the ratio between the first four antennal segments (1+2:3:4) is 1.16:1.03:0.63; and, in dried specimens, the height and length of the gaster is similar, but in some specimens the gaster is longer than high. In *N. quercusbatatus,* the genae are not broadened behind the eyes; the carina on the vertex is less distinct; the area around the antennal sockets is less depressed; the median carina on the frons is longer and reaches the antennal sockets; the ratio between the first four antennal segments (1+2:3:4) is 0.93: 0.77:0.57; and, in dried specimens, the gaster is higher than long. The phenology and gall structure of both species also differ (see biology section of both species).

Description.—Unisexual female: Brown to red brown, with dark brown to black gaster. Head piceous, from above about 2 times wider than long, broader than thorax, gena broadened behind eye; interocular space coriaceous, broader than high; distance between antennal sockets smaller than between eye and antennal socket; distinct carina on vertex reaching antennal sockets; frons coriaceous, broader than high, with densely and uniformly distributed short pale setae; median carina on frons indistinct, never extending between antennal sockets (like that in *N. quercusbatatus*); malar space well developed with deep malar groove; frons and clypeus lighter than rest of head, piceous; mouthparts of same color as frons and clypeus; tip of mandible black (Fig. 17). Antenna 13-segmented, longer than head and thorax together, pedicel and



Figs. 12–21. 12–16, *Neuroterus christi.* 12, Female head, front view. 13, Antenna of female. 14, Antenna of male. 15, Fore wing of female. 16, Shape and usual location of gall (3.5×). 17–21, *N. weldi.* 17, Female head, front view. 18, Antenna of female. 19, Fore wing of female. 20, Ventral spine of hypopygium of female, ventral view. 21, Shape of gall (2.5×).

scape flattened; scape slightly longer than broad; first 3 segments piceous, rest dark brown to black; ratio between first 4 segments (1+2:3:4) as 1.16:1.03:0.63 (Fig. 18). Scutum rounded, slightly longer than broad; brown, smooth and shining, finely coriaceous, without trace of notauli, anterior parallel, median, and parapsidal lines; posterior margin slightly emarginate on both sides from transverse groove at base of scutellum; groove distinct, with shiny bottom. Scutellum piceous, much lighter than scutum, rounded, slightly longer than broad, smooth, shiny, finely coriaceous, with few short and uniformly distributed pale setae. Pronotum and mesepisternum finely coriaceous. Median part of propodeum uniformly finely coriaceously punctate; sides similar. Fore wing translucent, with uniform very short pubescence, with cilia on margins, some specimens with only trace of smoky spot at junction of M to Cu_1 and on 2r-m; veins thick, brown, areolet large, triangular, Rs+M reaches M (Fig. 19); length 1.9-2.1 mm. Legs uniformly red brown, with black pretarsi; claws simple, without tooth. Gaster black, smooth, slightly longer than high; ovipositor tip hooked; hypopygium with few short sparse setae (Fig. 20). Length, 1.6-1.8 mm.

Comments.—Weld (1959) wrote of a stem swelling found on *Q. chapmanii,* but he never reared the adults and consequently did not describe the species. The galls induced by *N. weldi* are probably those Weld described.

Types.—Holotype ♀ and 17 ♀ paratypes. Air Force Range, Avon Park, Highlands Co., Florida, 9 February 1995, emerged 16 February 1995. Holotype and 4 paratypes in the USNM; 4 paratypes in AMNH; 9 paratypes in the private collection of G. Melika.

Etymology.—Named after the American cynipidologist L. H. Weld who probably first found the galls of this species.

Distribution.—Central and coastal sandridges of south central Florida (Archbold Biological Station, Lake Placid, Highlands Co.; Avon Park Air Force Range, Highlands Co.; Jonathan Dickinson State Park, Martin Co.).

Biology.—Only the unisexual generation is known. The gall is cylindrical, mostly a terminal stem swelling, covered with normal bark, on second year or older twigs and branches only of *Quercus chapmanii.* It is 25.0-40.0 mm long, 6.0-9,0 mm in diameter, and polythalamous (Fig. 21). Galls are not woody, rather they are easily cut like cheese. The leaf petioles are never involved in gall formation. Galls persist on stems for several years. Fully developed adults overwinter in galls and emerge from the second half of February into March of the following spring. The first galls observed are formed by the end of May.

Neuroterus quercusbatatus (Fitch)

Cynips Quercus-batatus Fitch 1859: 810. Females and males (type examined).

Neuroterus batata Basset: Ashmead 1885a: 296, 303.

Neuroterus batatus form *bisexualis* Kinsey 1920: 334.

Neuroterus (*Dolichostrophus*) *batatus* var. *batatus* form *bisexualis* Kinsey 1923: 4.

Neuroterus quercusbatatus: Burks 1979: 1074.

Cynips noxiosus Bassett 1881: 108. Females, males, galls of both generations (types examined). **New synonymy.**

Neuroterus noxiosus form *vernalis* Kinsey 1920: 337. Bisexual generation.

Diagnosis.—This species closely resembles *N. weldi*; see diagnosis for that species.

Redescription.—Female: Brown to red brown. Head from above 2 times broader than long, broader than thorax, gena only very slightly broadened behind eye; interocular space coriaceous, broader than high; distance between antennal sockets nearly same as distance between eye and antennal socket; frons coriaceous, broader than high, with uniformly distributed short pale setae; median carina on frons reaches between antennal sockets; malar space well developed with deep groove; frons, clypeus, and mouthparts of same color as rest of head, in some specimens lighter; tip of mandible dark brown to black. Antenna 13-segmented, brownish yellow, sometimes pale yellow, slightly longer than head and thorax together; 3 apical flagellomeres dark brown; pedicel and scape flattened; scape slightly longer than broad; ratio between first 4 segments (1+2:3:4) as 0.93:0.77:0.57. Scutum rounded, slightly longer than broad, brown black, smooth and shiny, finely coriaceous, without trace of notauli, anterior parallel, median, and parapsidal lines. Scutellum dark brown to black, rounded, only very slightly longer than broad, smooth, shiny, finely coriaceous, with densely and uniformly distributed pale setae; posterior margin slightly emarginate on both sides from transverse groove which is shiny. Pronotum, mesepisternum finely coriaceous. Medial part of propodeum uniformly coriaceously punctate; sides similar. Fore wing translucent, with uniform, very short pubescence, with cilia on margins; veins thick, brown, areolet large, triangular. Legs brown; coxae, centers of femora, and hind tibia somewhat darker; claws without tooth. Gaster larger than thorax, brown, sometimes brown black, usually same color as thorax and head, higher than long; ovipositor tip hooked, ventral spine of hypopygium with few short sparse white setae. Length, 1.2-2.2 mm. Females of both generations quite similar, impossible to distinguish them on basis of morphological characters. Male: Similar in color to female; thorax red brown laterally; legs and antenna uniformly yellow; gaster with petiole piceous or lighter in color; eyes only slightly enlarged; F1 not longer than that of female.

Distribution.—Ontario, Rhode Island, Connecticut west to Illinois, Colorado, south to Florida.

Biology.—Alternate bisexual and unisexual generations are known. Both generations induce stem-swelling galls on *Quercus alba* L. (Ashmead 1885a, Burks 1979). In Florida, the galls of the bisexual generation also develop on *Q. chapmanii* and *Q. margaretta.* The gall is a woody, elongate stem swelling. It is polythalamous, with an irregular shape and a surface that is covered by normal bark, twisted, but in large part cylindrical, tapering gradually to the stem at both ends and up to 20 mm long and 8 mm wide in the bisexual form and 60 mm long by 20 mm wide in the unisexual form. Sometimes several galls can more or less fuse, drying brown in bisexual forms, with a whitish or purplish bloom in unisexual forms. Internally hard and woody, the tissue is little modified except by the larval cells which are densely packed, each with a distinct but wholly inseparable lining. The unisexual form develops on young stems, involving petioles and leaf midveins; the bisexual form is on older stems involving the bases of the petioles. The unisexual form begins to develop in mid-summer, forming woody stem galls. The adults overwinter in the galls and emerge in spring after the oaks are actively growing. The galls of the bisexual generation are less woody, usually on younger twigs, and develop in late spring to early summer. The adults emerge in June and July.

Neuroterus quercusirregularis (Osten Sacken)

Cynips q. irregularis Osten Sacken 1861: 65. Species described from one damaged male (sex not certain) and one gall. Type lost.

Neuroterus irregularis: Ashmead 1885a: 296, 304.

Neuroterus quercusirregularis: Burks 1979: 1074.

Cynips quercus-majalis Bassett 1864: 683. Females, males, galls (types examined). **New synonymy**.

Neuroterus majalis: Mayr 1881: 37.

Neuroterus (*Dolichostrophus*) *irregularis* var. *majalis*: Kinsey 1923: 100.

Diagnosis.—This species is very closely related to *N. christi*; see diagnosis of that species. *Neuroterus quercusirregularis* is associated with the *Quercus chapmanii- Q. margaretta-Q. stellata* Wangenh. group, while the closely related *N. christi* is found only on *Q. virginiana* and *Q. geminata.*

Redescription.—Female: Head largely dark brown to black, finely coriaceous; gena not broadened behind eye; frons with uniformly distributed short pale setae; eyes enlarged, malar space very short with malar groove; clypeus rounded, emarginated posteriorly, slightly lighter than frons. Antenna brown, yellow to whitish basally, 13-segmented, F1 2 times or more longer than F2. Thorax black, only slightly longer than high or wide. Scutum and scutellum smooth, shiny, very finely coriaceous, without setae. Pronotum and mesepisternum finely coriaceous. Fore wing densely pubescent, much longer than the body, with cilia on margins; areolet usually moderate, but variable in size; with very light smoky spot a midpoint of M. Legs entirely pale yellow or whitish, semitranslucent; pretarsi black; claws without tooth. Gaster black or very dark brown, shining and smooth, higher than long. Length, 1.5-2.0 mm. Male: Head dark brown to black, lower part of frons lighter than in female; eye considerably enlarged, malar space very short. Antenna generally lighter than in female, pale yellow or yellow white, with F1 much lengthened, distinctly curved, 2 times longer than both pedicel and scape together and nearly 4 times longer than F2. Thorax considerably longer than in female, light brown, laterally yellow to whitish. Fore wing much longer than body. Legs whitish, semitranslucent. Male slightly larger than female.

Comments.—We found no evidence to differentiate *N. quercusirregularis* from *N. quercusmajalis.* Beutenmueller (1910) wrote about *N. quercusmajalis*: "Allied to *N. q. irregularis* in color . . ., and the only perceptible difference that I can find between the two species is in size." Bassett (1864) mentioned that is it quite similar to Osten Sacken's *C. q. irregularis,* but related to other species of oak. Kinsey (1923) treated *N. quercusmajalis* as a variety of *N. irregularis,* and described coloration as the only difference. Unfortunately, the type male of *N. quercusirregularis,* originally designated by Osten Sacken, is lost. Except for slight difference in coloration, we found no morphological differences between *N. quercusmajalis* and *N. quercusirregularis* in either sex. Consequently, we regard these species as synonymous.

Distribution.—Ontario, New York, Massachusetts, Connecticut, New Jersey, Maryland, Virginia, west to Illinois, Missouri, Oklahoma, Texas, and southward (Beutenmueller 1910). We found this species in North Carolina (vicinities of Arapahoe, Pamlico Co., on *Q. stellata*), and in Florida (common, locally abundant, occurs everywhere the host plants grow: Jonathan Dickinson State Park, Martin Co.; Archbold Biological Station, Highlands Co.; Winegarner's property in the vicinity of De Funiak Springs, Walton Co., and throughout the panhandle and south central Florida).

Biology.—Only the bisexual generation is known to induce integral leaf galls on *Quercus alba* and *Q. montana* Willd. (Ashmead 1885a, Beutenmueller 1910, Kinsey 1923, Weld 1959), and *Q. chapmanii* and *Q. stellata* (Burks 1979). We frequently found this species on *Q. margaretta* as well. According to Kinsey (1923), *N. quercusirregularis* var. *albipleurae* Kinsey induces galls on *Q. breviloba* (in Texas only). The gall is a leaf parenchyma thickening, with the larval cells mostly deeply embedded, and is polythalamous. It is usually elongate, oval, as thick as wide, up to 5.0 mm wide by 15.0 mm long, several galls often fusing, green, very succulent, shriveling considerably upon drying, and the larval cell has a distinct but inseparable layer. The galls are smooth and large when on *Q. alba* and the pubescence is denser and the galls are smaller when on *Q. stellata, Q. margaretta,* or *Q. chapmanii.* Galls usually appear on very young, unfolding leaves, very quickly mature, and develop from April until early June, earlier farther south. Adults emerge from May through July.

Neuroterus quercusminutissimus (Ashmead)

Cynips q. minutissima Ashmead 1885a: 7. Females only.

Neuroterus minutissimus: Ashmead 1885b: 296.

Neuroterus (*Diplobius*) *verrucarum* var. *minutissimus*: Kinsey 1923: 72.

Diagnosis.—The sculpture of the pronotum in *N. quercusverrucarum* is duller than in *N. quercusminutissimus*. The gaster in *N. quercusminutissimus* is sharply triangular, considerably higher than long, and smaller than the head and thorax together, while in *N. quercusverrucarum,* the gaster is more prolonged and nearly the same length as the head and thorax together. The gall resembles that of *N. quercusverrucarum*; however, the cynipid species composition on *Q. virginiana-Q. geminata-Q. minima* is very specific. No other host plants have been recorded for the 14 species of oak cynipids that occur on the closely related group of oak species. Thus, knowledge of the host species is very helpful in the identification of species. *Neuroterus quercusverrucarum* and *N. quercusminutissimus* are both very common in Florida; however, the former species is associated with *Q. chapmanii, Q. stellata,* and *Q. margaretta,* while the latter species is hosted by *Q. virginiana, Q. geminata,* and *Q. minima.*

Redescription.—Female: Entire body black, only clypeus and mandible light brown. Head from above 2 times wider than long, broader than thorax, gena only very slightly broadened behind eye; interocular space, vertex, and frons of same coriaceous sculpturing; frons with uniformly densely distributed short pale setae; malar space moderately large, with faint groove. Antenna 13-segmented, yellowish brown, F1 longest flagellomere, but only slightly longer than F2. Scutum and scutellum both rounded, shiny, very finely coriaceous, with very few short pale setae on scutum and with uniformly distributed dense short white setae on scutellum; without trace of notauli, anterior parallel, median, and parapsidal lines; transverse groove at base of scutellum large, with smooth, shiny bottom. Pronotum and mesepisternum same color as scutum, very finely coriaceous. Fore wing translucent, with cilia on margins, longer than body; veins thick, yellowish, only Rs+M much paler; areolet triangular, distinct. Legs yellowish brown; coxae, femora, and tibiae infuscated along upper surface; claws without tooth. Gaster black, shiny, higher than long, sharply triangular in outline; ovipositor straight, tip not hooked; ventral spine of hypopygium prominent, visible laterally. Length, 0.5-1.3 mm.

Distribution.—Florida. Common everywhere *Quercus geminata, Q. minima,* and/or *Q. virginiana* grows.

Biology.—Only the unisexual generation is known. This species induces small, 1.25-2.50 mm, detachable galls, covered with coarse, light brown mossy pubescence, on the underside of leaves in numbers in the fall on *Quercus geminata, Q. virginiana,* and *Q. minima.* In Florida, adults emerge early in the spring, but the galls do not develop until mid- to late summer. The fully grown adults overwinter in the galls.

Neuroterus quercusverrucarum (Osten Sacken)

Cynips quercus verrucarum Osten Sacken 1861: 62. Females and galls (types examined).

Cynips verrucarum: Osten Sacken 1865: 354.

Neuroterus verrucarum: Ashmead 1885a: 296, 304.

Neuroterus quercusverrucarum: Burks 1979: 1075.

Neuroterus exiguissimus Bassett 1900: 332. Females and galls (types examined). **New synonymy.**

Cynips flocossa Bassett 1881: 111. Females and galls (types examined). **New synonymy.**

Neuroterus verrucarum var. *pernotus* Kinsey 1923: 74.

Neuroterus flocossus: Burks 1979: 1073.

Diagnosis.—See *Neuroterus quercusminutissimus.*

Description.—Female: See description and diagnosis for *N. quercusminutissimus.* Length, 0.7-1.5 mm.

Comments.—We found no morphological differences in adults, galls, and phenology of *N. quercusverrucarum, N. exiguissimus,* and *N. flocossus;* consequently we treat them as synonyms. Kinsey (1923) described ten varieties of this species, one of which, *N. verrucarum* var. *restrictus* Kinsey, was from Florida on *Quercus chapmanii.* He indicated that this variety was collected also on *Q. margaretta* and *Q. geminata.* In our opinion, the latter reference concerns *N. quercusminutissimus.*

Distribution.—Ontario, New York, New Jersey, Connecticut, west to Illinois, Oklahoma, Texas, south to Florida.

Biology.—Only the unisexual generation is known. This species induces detachable leaf galls which are small, smooth, seedlike larval cells, hard, thin-walled, and covered with a dense flattened yellowish brown mass of wool that dries brown. The gall is monothalamous, attached to the underside of the leaf by a small point to the leaf vein, separable, but the leaf is depressed at the point of attachment. The average diameter of a gall is 2.0 mm by 1.0 mm high. The galls are usually numerous, covering the whole underside of the leaf and are found on *Quercus alba, Q. bicolor* Willd., *Q. chapmanii, Q. margaretta,* and *Q. stellata.* Viereck (1916) also recorded *Q. macrocarpa* Michx. as a host, but this must be confirmed. Galls begin to develop in September (Weld 1959). According to Kinsey (1923), the galls appear after mid-summer in August and the larvae do not mature until late in the fall. Adults emerge the next spring in February to March.

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OBSERVATIONS ON SOME HEMIPTERA/HETEROPTERA OF MACAU, SOUTHEAST ASIA

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Abstract.—The insect species of Macau are believed to be quite diverse in numbers of species due to trees and foliage representing the subtropical evergreen broadleaf forest as well as remnants of the monsoon tropical rain forest. The absence of land under agricultural production may account for the low numbers of some groups that are more common in the temperate regions of the world such as the Anthocoridae, Miridae, or Lygaeidae. Records of 59 species of true bugs are listed for the Portuguese territory of Macau of which 32 are considered new records.

Key Words: Macau, Hemiptera, Heteroptera, faunal list

The true bugs locally have been little studied since the time of J. C. W. Kershaw who lived in Macau for seven years and published a series of papers on local hemiptera and homopteran fauna (Kershaw and Kirkaldy 1908a, b, 1909a, b, c). The territory of Macau consists of a peninsula of land connected to the Guangdong Province of mainland China as well as two islands consisting of Taipa and Coloane which are connected to the peninsula either by bridges (Taipa, 2) or a causeway (Coloane). It is most likely that Kershaw carried out his observations on Macau insects on the peninsular area as road access to the islands was not available until 1974. Since that time urbanization has eliminated most of the agricultural habitats on the land area connected to mainland China and the majority of our records concern fauna of the islands where the urbanization process has been less intensive. Notes are provided in this paper on certain species in families the authors have observed in Macau over the course of years from 1989 to the present.

MATERIALS AND METHODS

Insects were sampled during all months of the year from an artificial light source built in 1994 at the entrance of the inner harbour on the Macau peninsula. The presence of 18 high intensity lamps (1800 watt) illuminating the 40 metre tall granite Friendship monument accounted for the fair number of records of which *Nezara viridula* (L.) (Pentatomidae) was found to be the most abundant species present. Other species were collected from the walls of buildings (Taipa island) that are normally illuminated at night while those species not sensitive to light were sampled from trees and shrubs upon visual examination. Names of the plant hosts follow the Macau Catalogue of Plants (Câmara Municipal das Ilhas, Macau and Instituto de Investigaçâo Científica Tropical, Lisboa 1991). Representatives of the species of Hemiptera named here are housed in the entomology museum of the Agrarian Services on Coloane island under the curatorship of the second author.

LIST OF SPECIES

HEMIPTERA

Acanthosomatidae

Dichobothrium nubilum (Dallas). 12 April 1994, Ip Tai leg, NEW RECORD, Coloane Island. In mainland China it is found in Hainan, Guangdong, Guangsi, Hunan, Sichuan Provinces as well as Tibet; also India, Taiwan and Japan.

Elasmostethus nobilus (Dallas). 18 April 1996, ERE leg, NEW RECORD, Friendship monument on Macau peninsula Also found in Hong Kong according to Tai Lung farm records.

Belostomatidae

Diplonychus rusticum F., small water bug. 18, 23, 25, 28, 30 May; 1, 12 June, 25 Aug. 1996, ERE leg, Friendship monument, Macau peninsula; male with eggs, Leung-va leg, Coloane island, NEW RECORD. Found in pond on reclaimed land. In Hong Kong Dudgeon and Corlett (1994) report it common in slow moving streams and marshes. It is found in India, Burma, Sri Lanka, Malaya, Sumatra, Java and Thailand as well as Australia.

Lethocerus indicus (Lepeletier and Serville), giant water bug. 24 Jan.; 10 June 1994; 5 May; 10, 19 June 1995; 19 June 1996, ERE leg, NEW RECORD, Macau peninsula. Hoffman (1933) studied its life history in Guangzhou; eggs were laid on upright vegetation in ponds. At lengths ranging from 60–80 mm it is the largest hemipteran known. Widespread in China it is also found in Burma, Sri Lanka, India, Java, Sumatra, Malaya and the Philippines.

Coreidae

Acanthocoris scaber (L.), brown coreid bug. 11 July 1994, Cheong Chi Keong leg, NEW RECORD, Coloane Island, ex *Capsicum frutescens, Ipomeae batatas, Lycopersicum esculatum* and eggplant, *Solanum melongena.* Hoffman (1931a) reported it damaging eggplant, squash and peppers in the Guangzhou area of SE China. Reported also in India.

Cletus trigonus (Thunberg), slender rice bug. 19 Sept. 1993. PWW leg, NEW RECORD, Coloane Island, ex *Amaranthus tricolor,* Chinese spinach. In addition to Guangdong Province of China it also occurs in India, Sri Lanka, Borneo and Philippines.

Gralliclava horrens (Dohrn), Oriental pod bug. 17 Aug. 1993, Ip Tai leg, NEW RECORD, Coloane Island, ex *Arachis hypogaea,* groundnut. Dolling (1978) revised the group and reported it from Hong Kong, India, China (Fukien, Hainan), Burma, Thailand, Borneo, Sulawezi, Philippines and Taiwan.

Homeocerus unipunctatus Dallas. Date, collector unknown. NEW RECORD, Coloane island, ex. *Glycine max, Phaseolus radiatus,* vetch. Wu (1935) reported it also in India, Sri Lanka, Burma, Malaya and Java.

Leptocorisa acuta (Thunberg), coreid rice bug. 12, 19 Nov. 1994, ERE leg, Friendship monument, Macau peninsula. It was reported earlier from Taipa island (Easton 1992). Sands (1977) recorded it from Southern Japan, Taiwan, Hong Kong, Vietnam, India, Pakistan, Thailand, Indonesia to Papua New Guinea, Samoa, Fiji and Australia.

Mictis tenebrosa F., cassia bug. 9 Aug. 1992, Ng Wai Man leg, NEW RECORD, Coloane Island, ex *Arachis hypogoea* and *Smilax china,* greenbrier. In Hong Kong there are records from *Cassia fistula* (Lee and Winney 1981). O'Shea and Schaefer (1980) reported it from India, Burma, Malaya and Indonesia as well as China.

Notobitus meleagris (F.), bamboo coreid or leaf-footed bug. 11 Oct. 1992, Ng Wai Man leg, Coloane island; 2 nymphs, 12 adults, 30 Aug 1995, ERE leg, ex *Dendrocalmus pulverulentus* bamboo in Lou Lim Iok gardens, Macau peninsula. Reported also in Hainan, China as well as India, Malaya and Hong Kong.

Paradasynus spinosus Hsiao, green coreid bug. 10 Nov. 1992, PWW leg, NEW RECORD, Coloane Island. In Hong Kong it has been found on *Citrus sinensis* and *Melia azedarach* (Lee and Winney 1981) and Hill et al (1982) observed the nymphs clustering on plant leaves.

Riptortis linearis (F.) 26 July 1995, J. Santos leg, NEW RECORD, Coloane Island. ex *Phaseolus radiatus* and *P. vulgaris,* kidney bean. Wu (1935) reported it from the Guangdong region of China as well as India, Sri Lanka, Burma and Malaya.

Cydnidae

Adrisa magna (Uhler), black burrowing bug. 12, 13 March; 3, 27 April 1994, ERE leg, NEW RECORD, Friendship monument, Macau peninsula. It is also recorded from Northeast India Burma and Hong Kong.

Dinidoridae

Cyclopelta obscura (Lepeletier and Serville). 22 Sept. 1992 Ng Wai Man leg, NEW RECORD, Coloane Island, ex *Canavalia gladiata,* sword bean and *Cercis chinensis,* Chinese redbud. Distribution is India, Burma, Cambodia, Laos, Vietnam, Indonesia, Malaysia, Philippines and China (Durai 1987).

Megymenum inerme (Herrich-Schaeffer). 1 Aug. 1994, Ng Wai Man leg, Coloane Island. Originally reported in Macau by Kershaw (in Kirkaldy 1910). Also found in India, Sri Lanka Vietnam, Thailand and Guangzi, Guangdong, Hebei and Yunnan provinces of China.

Gerridae

Aquarius paludum (F.). Summer 1993, ERE and Leung-va leg, NEW RECORD, Coloane Island in pond on reclaimed land at Siac Pai Van; 21 Aug. 1996, Friendship monument, Macau peninsula attracted to lights. Chen and Andersen (1993) report it from most provinces of China and it is believed to range across Eurasia from Britain to Japan. These authors also reported another species in Macau, namely *Limnogonus fossarum* (F.) but we did not collect it in this study.

Largidae

Physopelta gutta Burmeister. 28 Oct. 1992, Cheong Chi Kong leg, Coloane island; 13 Feb.; 16, 27 March; 3, 6, 12 April 1994, ERE leg, Friendship Monument, Macau peninsula attracted to light. On the island of Taipa and in neighboring Hong Kong it has been noted (Easton 1992) feeding on the seeds of the turn-in-the-wind tree, *Mallotus paniculatus,* that mature during the colder months of the year. Mating was observed on the trunk of this tree and all immature stages noted on the tree foliage at this time. It is apparently widespread in South East Asia found in Sri Lanka, India, Burma, Vietnam, Bangladesh, Indonesia, China (Guangdong, Hunan, Sichuan, Yunnan provinces), Tibet, Philippines, Taiwan and east to Australia.

Lygaeidae

Horridipamera nietneri (Dohrn). 13 Aug. 1996, ERE leg, NEW RECORD, Friendship Monument, Macau peninsula. In India, Mukhopadhyay (1988) reported it from grass and litter of *Ficus* species. It is also found in the Guangdong Province of China and reported as far southeast as Australia.

Metochus abbreviatus (Scott). 24 Aug. 1992, Cheong Pak Fai leg, Coloane Island; 10 Nov 1990, ERE leg, Taipa Island NEW RECORD ex. *Camellia oleifera,* oil tea and *Vernicia montana,* wood-oil tree. It is commonly attracted to lights. Distributed in India, China (Hunan, Guangxi, Jiangxi, Sichuan) Taiwan and Japan.

Metochus uniguttatus (Thunberg). 28 March 1996, ERE leg, Friendship monument, Macau peninsula. Easton (1992) reported it from a building that had been illuminated at night on the island of Taipa. There are also specimens collected from Hong Kong at the Tai Lung farm experimental station near Sheung Shui.

Paromius exiquus (Distant). 13 Aug. 1996, ERE leg, NEW RECORD, Friendship monument, Macau peninsula attracted to lights. Distribution includes India (Mukhopadhyay 1988).

Thunbergia sp. 27 July 1991, ERE leg, Taipa island, attracted to lights on the university campus.

Nabidae

Nabis stenoferus Hsiao. 15 Aug. 1992, PWW leg, NEW RECORD Coloane island. Also distributed in Hunan, Jilin, Shanxi, Shandong and Yunnan provinces of China.

Notonectidae

Enithares biimpressa (Uhler). 6 June 1992, ERE leg, NEW RECORD, Coloane island from small stream emerging from mine shaft in ravine above Choec-van village. It has been previously only reported from Hong Kong (D. Polhemus, personal communication).

Pentatomidae

Calliphara nobilus (L.), blue shield bug. 15 Aug. 1991, ERE leg, ex *Ficus sp.* near entrance of mine shaft above Choec-van village feeding on fruit. It was first reported in Macau by Kirkaldy (1910). Distribution includes Hong Kong, Borneo, Burma, Malaysia, Java, Taiwan and the Philippines.

Cantao ocellatus (Thunberg). 5 Nov. 1994, ERE leg, Friendship monument, Macau peninsula. Easton (1991) reported numerous individuals on the island of Taipa resting and mating during winter months on the fruit and among foliage of *Mallotus paniculatus* (Euphorbiaceae). Eggs and nymphs have not been observed in this study nor in nearby Hong Kong where similar behaviour has been reported but in India, parental care has been noted (Ayyar 1920) and feeding occurred on the tender leaves and fruit of *Trewia nudifolia* (Euphorbiaceae), a plant not found in this area. The insect furthermore in India was observed congregating on the branches and so believed to be important in the pollination of the moon tree, *Macaranga roxburghii* (Schuh and Slater 1995), another plant species not believed to occur locally or in Hong Kong. It is believed to be distributed in Bhutan, Thailand, Burma, Borneo, Java, Vietnam, Sumatra, Malaysia and the Philippines as well as Taiwan and southern Japan.

Chrysocoris stollii (Wolff). 7 July 1994. Cheong Chi Kong leg, NEW RECORD, Coloane Island, ex *Glochidium* and *Schima superba.* Kershaw reported it first from Macau (in Kirkaldy 1910). It is also found in Hong Kong, India, Java, Sumatra and the Kwangsi province of China. Another species *Chrysocoris grandis* (Thunberg), large white shield bug was collected by J. C. Kershaw 1910, but not found in the present study.

Dalpada oculata (F.). 27 April 1993, Cheong Pak Fai, leg, Coloane Island, ex *Cunninghamia lanceolata* and *Paulownia fortunei.* Kershaw reported it originally (in Kirkaldy 1910) It is also found in the Hainan province of China as well as in India, Burma, Malaysia and Hong Kong.

Eocanthecona concinna (Walker). Hoffman (1935) listed it from both Hong Kong and Macau but it was not observed in the present study.

Eocanthecona furcellata (Wolff) grey stink bug. 19 Aug. 1991, ERE leg, NEW RECORD, Taipa island. A predaceous asopine that feeds by inserting its stylets into soft-bodied lepidopterous larvae. A mass rearing technique has been developed to control cutworms in Thailand (Napompeth 1992), and, in Hong Kong, it has been observed feeding on the fall armyworm. Distribution includes India, Sri Lanka, Bangladesh, Burma, Java, Taiwan, China to Japan (Thomas 1994).

Erthesina fullo (Thunberg), yellow spotted stink bug. A common species locally observed feeding on the trunks and stems of *Casuarina equisetifolia* trees where mating and oviposition take place by cementing two or more leaves together (Easton 1993). First reported locally by Kershaw and Kirkaldy (1909c) who described the immature stages and provided biological notes. In the Guangzhou area of China, Hoffman (1930) reported it feeding upon 30 species of trees of which the tallow tree, *Sapium sebiferum* was the first choice followed by the Chinaberry, *Melia azedarach* and *C. equisetifolia.* Its distribution includes India (Assam), Sri Lanka, Burma (or Myanmar), Malaysia, Java, Hong Kong, Taiwan and Japan.

Halyomorpha picus (F.). 1 Aug. 1991, ERE leg, Taipa Island. Hoffman (1931a) reported it as a pest of *Vigna sesquipedalis* yard-long bean and *Phaseolus lunatus,* lima beans near Guangzhou, China. We believe Kershaw (in Kirkaldy 1910) was the first to report it from Macau. It also occurs in Hong Kong according to specimens at the Tai Lung Experimental Station. Its distribution includes India, Sri Lanka, Burma, Vietnam, Malaysia and Taiwan as well as Guangdong province of China.

Megarrhamphus hastatus (F.). 10 May 1997, ERE leg, Taipa Island hiking trail, Ex *Miscanthus* grass. Kirkaldy (1910) listed it for southern China.

Melanophara dentata Haglund. Reported in Macau by Kirkaldy (1910) but it has not been collected in our study.

Nezara viridula (L.), the green vegetable bug. One of the most common insects found locally. Four colour varieties have been observed in recent years. Of a total of 460 specimens collected from the lights of the Friendship monument (Aug. 21–Sept. 8, 1996) an entirely green form comprized the majority of specimens (85% of 460). A second form characterized by a yellowish pronotum on a entirely green body accounted for 13% while a 3rd form yellow on the dorsal surface with green spots was the least abundant (1.5%).

Only one individual has been observed of the entirely yellow form which was characterized by Chen (1980) and entered a New Jersey Light trap on Taipa Island (1 Sept 1991). We believe Kirkaldy (1910) was the first to report the apparently all green form of this bug in Macau. Hosts of the insect are numerous including *Brassica campestris, B. oberacea, B. pekinensis, Oryza sativa* and *Azukia mungo.*

Piezodorus hydneri (Gmelin), the soybean stinkbug. 9 May 1996, ERE leg. Kirkaldy (1910) was first to record it locally. In Hong Kong it is reported from *Glycine max* or *G. soja* (Lee and Winney 1981).

Plautia fimbriata (F.), the string-bean stinkbug. 8–10/tree 25 June 1996, ERE leg, NEW RECORD, Taipa island, ex *Clerodendrum fragrens,* fragrant glorybower on hiking trail feeding on flowers. In Hong Kong it has been recorded feeding on *Vigna sesquipedalis,* yard-long bean as well as in the Guangdong region of China. It is also found in India, Sri Lanka, Burma, Malaysia and Japan.

Rhynchocoris humeralis (Thunberg), the citrus shield bug. 19 Nov. 1994, ERE leg, Friendship Monument, Macau peninsula August 1996, Coloane island NEW RECORD ex *Citrus sinensis.* Hoffman (1931b) studied its life history in the Guangzhou area of China and noted feeding on fruits in all stages of development causing fruit drop. It is found in India, Sri Lanka, Burma, Thailand, Hong Kong and the Hainan, Guangdong, Guangxi Fujian, Yunnan and Sichuan Provinces of China as well as Taiwan and Laos.

Stollia guttigera (Thunberg). 14 Sept. 1993, PWW leg, Coloane Island. Kirkaldy (1910) listed it earlier for Macau. Hosts include *Amaranthus gracilus, Arachis hypogaea, Avena fatua,* wild oats, *Celosia argentea,* wild coxcomb, and *Morus alba.* It is found in the Guangdong region of China.

Tetroda denticulifera Bergr, fork-headed stinkbug. 14 June 1993, Taipa island; 13 Sept. 1991, ERE leg, Ka-Ho village, Coloane island, NEW RECORD. In Hong Kong it has been recorded from *Oryza sativa.* Generic placement is considered to be *Tetrodias* according to Ahmad and Kamaluddin (1992).

Tolumnia latipes Walker. 27 April 1994, Cheong Pak Fai leg, Coloane Island, ex *Eucalyptus robusta,* swamp mahogany. Kershaw (in Kirkaldy 1910) may have recorded it both in Hong Kong and in Macau as *T. latipes* (Dallas). Distribution includes India, Burma, Vietnam, Malaysia, Sumatra, Java, Taiwan and the Hunan, Zhejiang, Jiangxi, Hubei, Sichuan, Fujian, Guangxi, Yunnan and Guangdong provinces of China.

Udonga spinidens Distant. 6 April 1995, ERE leg, NEW RECORD, Friendship monument, Macau peninsula. It is widespread in China found in the Fujian, Hubei, Hunan, Guangxi, Guangdong, Shangxi and Yunnan provinces as well as Vietnam and Japan.

Zicrona caerulea L. Kershaw and Kirkaldy (1909b) reported it in Macau feeding on the chrysomelid beetle, *Haltica coerulea Olivier* but it was not found in the present study. In Hong Kong it has been recorded from *Oryza sativa* (Lee and Winney 1981). It is apparently widespread in China (Wu 1935) and found also in Burma (Myanmar), Malaysia, India (Assam), Pakistan, Borneo, Java, Sumatra, Vietnam and Taiwan.

Plataspidae

Brachyplatys subaeneus (Westwood). 1 June 1994, PWW leg, Coloane Island. Kershaw (1910) reported it feeding on the Kudzu vine, *Pueraria thunbergiana* in Macau and Hoffman (1931a) reported it on lima beans in the Guangdong region of China. It is also found in the Hainan province of China as well as India, Thailand, Cambodia, Malaysia, Burma, Borneo, Sumatra, Java, the Philippines and Taiwan.

Coptosoma cribraria (F.) (= *Megacopta cribraria* (F.)). 8 Aug. 1994, Cheong Chi Kong leg, Coloane Island. Kershaw (1910) reported it in Macau. It is believed to feed upon vetch, *Phaseolus radiatus,* and kidney beans, *P. vulgaris* in the Guangdong region of China. Also found in India, Sri Lanka, Burma, Thailand, Java, Sumatra, Hong Kong and Taiwan.

Coptosoma variegata Herrich-Schaeffer. 5 May 1994, Ip Tai leg, NEW RECORD, Coloane Island. Also found in India, Sri Lanka, Burma, Java, Borneo, Sumatra, Thailand and the Philippines (Wu 1935).

Pyrrhocoridae

Dindymus rubiginosus sanguineus (F.). 15 Nov., 9 Dec. 1990; 20 Jan. 1991 ERE leg, Guia Hill on Macau peninsula. The first records of this bug in Macau were by Kershaw and Kirkaldy (1908a) who observed nymphs and adults feeding on thin-shelled gastropods, lepidopterous larvae, and hemipterans. Easton (1992) observed the bug feeding on a worker ant near the base of *Pawlownia fortunei,* Foxglove trees in a forested area on the Guia hill. Feeding also was noted on bugs of the same species at this site that may have first been injured or trampled by man. It is reported to occur in India (Assam), Burma, Thailand as well as Hong Kong (Wu, 1935).

Reduviidae

Ectomocoris apicimaculatus Distant. 7 Sept. 1995, ERE leg, NEW RECORD, Friendship Monument, Macau peninsula. It is also found in Hong Kong according to records at Tai Lung Experimental Station, Sheung Shui.

Ectomocoris atrox (Stal). 27 April 1993, Ng Wai Man leg, Coloane Island; 14 Sept. 1995, ERE leg, Friendship Monument, Macau peninsula, NEW RECORD. Hua (1984) recorded it from the Guangdong and Hainan provinces of China and Maldonado Capriles (1990) recorded it from Burma, Vietnam, Malaysia, Indonesia, India as well as China and the Philippines. This genus (Schuh & Slater 1995) consists of species that are ground-dwelling, and they are fast moving bugs that can inflict a painful bite to man.

Ectrychotes andreae (Thunberg). 2 April 1993, Tong Veng Va leg, NEW RECORD, Coloane Island. The bugs in the subfamily Ectrichodinae are believed to be obligate predators of millipedes (Louis 1974) and this species is found in the Guangdong and Hainan provinces of China (Hua 1984) as well as Taiwan, Korea, Japan and the Indochinese area (Maldonado Capriles 1990).

Oncocephalus impudicus Reuter. 14 Sept. 1995, 15 Feb. 1996, Friendship Monument, Macau peninsula; 30 Sept 1990, Univ. E. Asia, Taipa Island, ERE leg, NEW RECORD. Its distribution includes Borneo, Java and Sumatra in Indonesia, Sri Lanka and the Guangzhou area (Guangdong) and Hainan provinces of China.

Polididus armatissimus Stål. 9, 14 Sept, 1995, ERE leg, NEW RECORD, Friendship Monument, Macau peninsula. Its distribution includes India, Sri Lanka, Burma (Myanmar) Vietnam, Malaysia and the Fujian, Jiangxi, Hubei, Zhejiang, Guangxi, Guangdong and Hainan provinces of China.

Scadra costalis (Lethierry). 4 June 1996, ERE leg, NEW RECORD, Coloane island crossing road on premises of the Macau Golf and Country Club near Hac-sa village. This genus is also believed to feed upon millipedes which are quite common locally.

Sycanus crocevittatus Dohrn. 12 Aug. 1996, ERE leg, on causeway between Taipa and Coloane islands. Kershaw (1909) discussed oviposition and development of this bug in South China (probably included Hong Kong and Macau) and Hill et al. (1982) in Hong Kong discussed it feeding when a nymph on snails. It is found in India and Burma as well as islands off the coast of Guangdong province and on Hainan island (Hua 1984).

Triatoma rubrofasciata (DeGeer). 23 Aug. 1995, ERE leg, Taipa island attracted to lights on the University campus. Easton (1992) noted several individuals under rocks on the ground surface near a rodent harborage. Usinger (1944) pointed out that even though its distribution is currently tropicopolitan it is considered an old world species and probably Indian in origin. It occurs in Hong Kong as well as Hainan island.

Tribelocephala walkeri China. 15 July 1972. Chan Chi Man leg, NEW RECORD, Coloane Island. It occurs in Hong Kong (Maldonado Capriles 1990) and Hua (1984) reported it from islands off the coast of the Guangdong province.

Tessaratomidae

Tessaratoma papillosa (Drury), litchi stinkbug. 11 Nov. 1992, Ng Wai Man leg, Coloane Island; 5 Sept. 1994, ERE leg, Taipa island. Kershaw and Muir (1909) were probably the first to record it from Macau. It is common locally and in Hong Kong on both longan (*Euphoria longan*) and lychee, *Litchi chinensis* fruit trees where ever they occur. Considered a pest of fruit trees, biological control has been achieved by the mass rearing and release of an egg parasite, *Anastatus japonicus* Ashmead (Eupelmidae: Hymenoptera) in Hong Kong and in the Guangdong province of China as well as in Thailand (Napompeth 1992). It is also found in India, Sri Lanka, Burma, Thailand, Java, Sumatra and the Philippines.

Tingidae

Stephanitis pyrioides (Scott). azalea lace bug. 25 Mar. 1994, PWW leg, NEW RECORD, Coloane Island. In Hong Kong this species has been collected from *Rhododendron indicum* (Lee & Winney 1981), and there are records from Purple azaleae, *R. pulchrum,* in the Tai Lung farm entomology collection.

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NOTE

Acoptus suturalis LeConte (Coleoptera: Curculionidae: Zygopinae), a Potential Vector of the Chestnut Blight Fungus, *Cryphonectria parasitica* (Murrill) Barr, in the Eastern United States

American chestnuts trees, *Castanea dentata* (Marshall) Borkhausen, were once a widespread and important component of forests throughout the eastern United States. Following the introduction of the chestnut blight fungus, *Cryphonectria parasitica* (Murrill) Barr, into this country early in the century there was a rapid and dramatic decline in the abundance of these trees (Anagnostakis 1994. Advances in Botanical Research 21: 125–145). In an attempt to reestablish this species in forests and orchards there has been an exhaustive search for blight-resistant tree strains by cross-breeding with other species of *Castanea* (Anagnostakis 1994). More recent studies suggest that infected chestnuts inoculated with certain hypovirulent strains of the fungus are less susceptible to severe canker-induced damage (Anagnostakis 1994). Hypovirulence, caused by infection of the fungus with a double-stranded RNA virus or hypovirus, reduces the fungus damage to trees. Transgenic fungal strains have been produced that have a cDNA copy of the Hypovirus genome integrated into the genome of the blight fungus (Choi and Nuss 1992. Science 257: 800–803). These hypovirulent strains have the potential to effect a stable biological control of chestnut blight.

Dissemination of these hypovirulent strains outside the area of test plots will depend upon naturally occurring dispersal agents. Since insects, and particularly beetles, are known to harbor hypovirulent strains (Russin et al. 1984. Journal of Economic Entomology 77: 838–846) we were interested to find large numbers of the weevil *Acoptus suturalis* LeConte (Coleoptera: Curculionidae: Zygopinae) feeding upon chestnut cankers in an experimental plot (150 m × 80 m) in the Housatonic State Forest (Sharon township, Litchfield county, 73 22 30W × 41 52 40N, elevation 395 m) in northwestern Connecticut. In this forest test plot, pairs of American chestnut trees, AB to WX, were used in a study of the effect of virulent strains of the blight fungus. The first tree of each pair was treated with a transgenic hypovirulent strain, with resistance to hygromycin as an additional marker.

The vast majority of curculionids feed upon the living tissue of diverse structures of plants, although a considerable number are associated with decaying wood or fungi. Little is known about the feeding associations for zygopine weevils, although adults are often found in the vicinity of rotting wood, so the presumption is that the larvae develop in this habitat (Hespenheide 1995. Memoirs of the Entomological Society of Washington 14: 145–154). Lyal (1986. Journal of Natural History 20: 789–798) observed species of mecopine and metialmine Zygopinae ovipositing in the bark of fallen trees in southeastern Asia. The zygopine weevil *Acoptus* LeConte, a monotypic genus, is represented by *A. suturalis* and is widely distributed in eastern North America. Adults of this species have been taken from *Quercus* sp., *Cercis canadensis* L., *Carya* sp., and *Platanus occidentalis* L. (Sleeper 1963. Bulletin of the Southern California Academy of Sciences 62(4): 209–220), and from chestnut (Russin et al. 1984). Additionally, Chittenden (1890. Entomologica Americana 6: 167–172) reported *Acoptus suturalis* adults and supposedly conspecific larvae living in the dead wood of beech trees *(Fagus* sp.).

Fig. 1. *Acoptus suturalis* feeding on chestnut blight cankers infected with a hypovirulent transgenic strain of *Cryphonectria parasitica.*

Acoptus suturalis weevils were observed in Connecticut grazing on the fungal stromata in the *Cryphonectria parasitica* cankers on American chestnut trees (Fig. 1) in the test plot which is surrounded by oak-chestnut forest. These weevels were not observed on other woody plants in the plot. Trees in the overstory are *Quercus coccinea* Muench., *Acer rubrum* L. and *Populus* sp., while woody plants in the understory include *Carya glabra* (Miller) Sweet, *Quercus prinus* L., *Acer pennsylvanicum* L., *Hamamelis virginiana* L. and an *Ulmus* sp. One of us (SLA) collected 36 weevils (although many others were observed in the test plot), surface sterilized them with a 10% bleach solution, and squashed and spread them on water agar. Of 280 fungal isolates, 13 were hygromycin resistant, indicating that they contain transgenic DNA. These observations suggest that *Acoptus* weevils may play a role in controlling chestnut blight in eastern North America since the abundance of these weevils in test plots suggests their potential for spreading a transgenic hypovirulent strain which may eventually help to control chestnut blight.

Acknowledgments.—We are indebted to Henry A. Hespenheide (University of California, Los Angeles) for information about zygopine weevil biology and some relevant literature. We thank Horace R. Burke (Texas A & M University), Joseph V. McHugh (University of Georgia), P. Sletten and J. Shepard (The Connecticut Agricultural Experimental Station, New Haven), and Allen L. Norrbom (Systematic Entomology Laboratory) for reviewing this manuscript. This research was supported, in part, with funds from the Cooperative State Research, Education, and Extension Service, U. S. Department of Agriculture, under agreement No. 95-37312-1638.

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NOTE

Parasa indetermina (Boisduval) (Lepidoptera: Limacodidae), a new host for *Systropus macer* Loew (Diptera: Bombyliidae)

This note adds a new species to the published limacodid hosts of *Systropus macer* Loew (Diptera: Bombyliidae). Host literature for worldwide *Systropus* was reviewed by Adams and Yanega (1991, Journal of the Kansas Entomological Society 64:443–444). All North American records have been restricted to the eastern U.S. and are reported only for *S. macer*. Forty-nine species of Limacodidae are known from North America north of Mexico, accounting for synonymies from Epstein and Becker (1993, Revista brasileira de Zoologia 10:289–319) and a newly established species in southern Texas (Ferguson and Knudson 1987, Journal of the Lepidopterists' Society 40:353–355). Of these species, only four have been reported as hosts for *Systropus: Euclea delphinii* (Boisduval), *Adoneta spinuloides* (Herrich-Schäffer), *Prolimacodes badia* (Hübner), *Lithacodes fasciola* (Herrich-Schäffer), and an unidentified larva of *Apoda* Haworth (Adams and Yanega 1991). There are no additional unpublished host records for *Systropus* in the collection of the National Museum of Natural History, Smithsonian Institution (USNM), presently on loan to the Bishop Museum (Neal Evenhuis personal communication).

Larvae of *Parasa indetermina* (Boisduval) and one larva of *Euclea delphinii* (Boisduval) were found feeding on bayberry near Higbee Beach, Cape May, New Jersey on Sept. 23–24, 1995. All spun cocoons over the following several weeks. Adults of the non-parasitized cocoons all emerged in June 1996. The larva of *S. macer* inside the cocoon of *E. delphinii* was discovered in early June 1996 and was kept in a 2 dram vial. It did not pupate until 10 July 1996. It emerged along with the other individuals that parasitized *P. indetermina* between 10–15 August 1996. One individual per cocoon emerged in characteristic fashion, by pushing open the lid of the cocoon, as occurs for the limacodids. Five out of 17 cocoons of *P. indetermina* produced *Systropus* adults.

Additional New World species of *Parasa* that are hosts of *Systropus* sp. are *P. wellesca* Dyar and *P. cuernavaca* Dyar from Guanacaste, Costa Rica (D.H. Janzen and W. Hallwachs Lepidoptera rearing record database). There are no records of *Parasa* parasitized by *Systropus* in a review of bombyliid parasitoids of Southeast Asian limacodids by Greathead (1987, pp. 195–196. *In* Cock, Godfray and Holloway, eds., Slug and Nettle Caterpillars. CAB International). However, several species in the African limacodid genus *Latoia* (as *Parasa*) have been reported as hosts (Bowden 1967, Journal of the Entomological Society of Southern Africa 30:126–173).

Published limacodid hosts of North American and Asian *Systropus* consist of both smooth (= gelatine) and spiny type larvae; examples of smooth larval hosts include *Prolimacodes* Schaus, *Lithacodes* Packard and *Chalcocelis* Hampson (Adams and Yanega 1991; Greathead 1987). Records from Mexico south to Argentina are exclusively from the spiny genera *Acharia* (=*Sibine*) Hübner and *Miresa* Walker (literature reviewed by Adams and Yanega 1991) and the two *Parasa* species above. This probably reflects a collecting bias for brightly colored spiny larvae, which tend to be agricultural pests, compared to the cryptic smooth larvae.

I thank Jane Ruffin (Rosemont, PA) for discovering and showing me the population of *Parasa indetermina* and Neal Evenhuis (Bishop Museum) for determining the specimens of *S. macer,* providing helpful bibliographic information and searching the USNM collection for host information.

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99(3), 1997, pp. 586

NOTE

Replacement Names for Western Hemisphere Genera of Doryctinae (Hymenoptera: Braconidae)

Recently I published descriptions of several new genera of Doryctinae from the Western Hemisphere (Marsh 1993. Contributions of the American Entomological Institute 28(1): 1–58). Unfortunately, three of these generic names have been previously used and must be replaced with new names. Therefore, I propose the following new generic names.

Cyphodoryctes Marsh, **new name.** Replacement name for *Cyrtonion* Marsh 1993, not *Cyrtonion* Hansen 1989 (see Hansen 1991. Kongelige Danske Videnskabernes Selskab Biologiske Skrifter 40: 1–367). The original name *Cyrtonion* was derived from the Greek *kyrton* meaning humpbacked in reference to the mesonotum which anteriorly is swollen and strongly declivous. The replacement name is derived from the Greek *kyphos* also meaning humpbacked.

Donquickeia Marsh, **new name.** Replacement name for *Quickia* Marsh 1993, not *Quickia* Odhner 1950 (see Vaught 1989. A classification of the living Mollusca. American Malacologists, Inc.).

Whitfieldiellus Marsh, **new name.** Replacement name for *Whitfieldia* Marsh 1993, not *Whitfieldia* Davidson 1882 (see Moore, ed., 1965. Treatise on invertebrate paleontology. Part H, Brachiopoda. Vols. 1 and 2. The Geological Society of America and the University of Kansas).

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NOTE

Gender Correction for a Louse (Phthiraptera: Menoponidae) from Cormorants

Eichler (1950, Rivista di Parassitologia 11: 106) described *Piagetiella caputincisa* (Phthiraptera: Menoponidae) as a new species, with the type host being the blue-eyed cormorant, *Phalacrocorax atriceps* King. The agreement of the specific with the generic name is obvious, as both are feminine. Subsequent workers have been consistent in perpetuating the spelling given by Eichler. These include Hopkins and Clay (1952, British Museum (Natural History): 292) in their check list of the genera and species of chewing lice, Price (1970, Canadian Entomologist 102: 401) in his revision of the genus *Piagetiella,* Clay and Moreby (1970, Pacific Insects Monograph 23: 219) in a listing of lice of subantarctic islands, and Robinson (1984, British Museum (Natural History) Publication Number B2 0955: 31) in a checklist of insects of the Falkland Islands. To the best of our knowledge, all published references to this species have spelled it with the species in the feminine gender.

The late George C. Steyskal, in his efforts to put Latin ignorami on the right path, wrote to explain to us the error of our ways in considering "*caputincisa*" as the correct form. According to him, "*caputincisa*" represents a noun-phrase in apposition and the adjective "*incisa*" refers to "*caput*", which is a neuter noun. Therefore, the correct spelling for this scientific name must be *Piagetiella caputincisum.* Rather than simply change this spelling in our future references to this species, we thought it prudent to call attention as to why we are taking this action and remove any doubt that we may have committed a typographical error in so doing.

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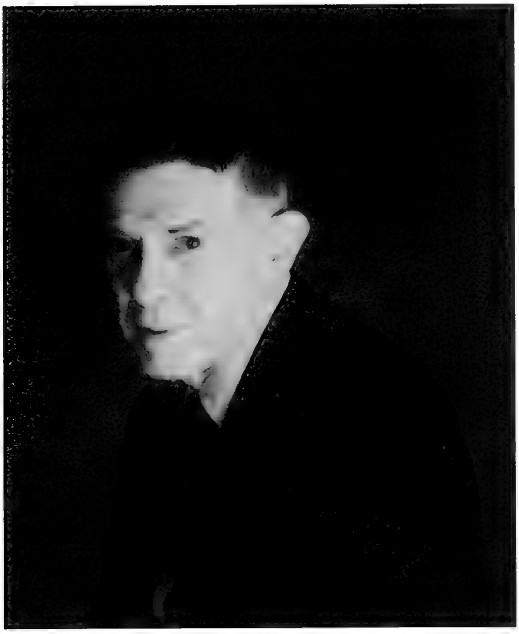
ROBERT TRAUB (1916–1996): AN APPRECIATION



Historians are fond of reminding us that the nineteenth century effectively began with Wellington's victory at Waterloo in 1815 and ended with the guns of August 1914. But do they know that the twentieth century also has ended off schedule? At least for medical entomology, the curtain fell on 21 December of last year, when we lost Dr. Robert Traub, Colonel, U.S. Army (Retired), the greatest authority on fleas and flea-borne diseases who ever lived and one of the most influential medical entomologists of this—or any—century. In months ahead, Dr. Traub's panegyrists will be legion, and formal obituaries may be expected in scores of scientific journals and societal newsletters worldwide. This is not one of them. It is, rather, a reminiscence, an anecdotal adieu to both a preeminent intellect and a charming personality.

It has been said that success in life is largely a matter of luck, in which case Robert Traub was lucky from the cradle, for he was born on 26 October 1916 in the Borough of New York (Manhattan), the cultural center of a city universally renowned for its tolerance and generosity. Unfettered by provincialism and imbued from childhood with a passion for natural history, Traub soon secured what was, for his generation, the Holy Grail of academe: admission to the City College of New York, which, by virtue of being tuition-free, attracted the cream of America's youth throughout the Great Depression. Success at City College in 1938 (B.S. in biology, cum laude) was Traub's entrée to the Ivy League; the following year, Cornell University awarded him an M.S. in his chosen métier of medical entomology. But just three months after the commencement ceremonies, Hitler unleashed 52 divisions against Poland, and entomologists everywhere felt the blow.

Paradoxically, the massive deployment of Allied forces during World War II heralded medical entomology's golden age, particularly in tropical Asia. Dispatched as a young Army officer to the China-Burma-India Theater, Traub's attention soon focused on a mysterious illness initially dubbed "CBI fever" that turned out to be scrub typhus (chigger-borne rickettsiosis, tsutsugamushi disease), an often fatal infection that was feared more than malaria because its etiology was unknown. Working at the United States of America Typhus Commission laboratory in Myitkyina, North Burma, and, after the war, at the U.S. Army Medical Research Unit, on the grounds of the Institute for Medical Research, Kuala Lumpur, Malaya, Robert Traub and his American and British collaborators clarified the intricate ecology of this disease and ultimately defeated it with the potent new antibiotic chloromycetin (chloramphenicol). These epochal advances in typhus research earned Traub's team a nomination for the Nobel Prize in 1948.

Acarologists will always claim Robert Traub as one of their own. Yet, even while he immersed himself in mite studies (publishing over his lifetime 66 papers on chiggers and chigger-borne rickettsiosis, including descriptions of 124 new chigger species), Traub was cultivating his lifelong enthusiasm for what his friend and mentor Karl Jordan (1861–1959) called "those jolly insects": fleas. Indeed, four new species of North American fleas were the subject of Traub's first scientific paper, published by the Field Museum in 1944, while its author was away pursuing acarines in the Burmese jungles (fleas will also be Traub's swan song, in the form of a co-authored chapter in a new textbook of medical and veterinary entomology slated to appear next year). Tellingly, 31 of Traub's 91 papers on fleas and flea-borne diseases were written in his spare time during a military career (1942–1962) that kept him otherwise occupied.

And what occupations! While with the Army, Traub completed his Ph.D. at the University of Illinois (1947), in the company of his confrere Harry Hoogstraal (1917–1986), whose name will forever be a mantra in medical acarology. After the Army, Traub accepted a professorship in the Department of Microbiology, University of Maryland School of Medicine, Baltimore, subsequently leading or participating in 14 research expeditions on four continents. During both careers, his published contributions, many of book length, on fleas, mites, mosquitoes, leeches, even amebiasis, as well as on a vast range of host and reservoir vertebrates, defined the state of the art in parasitology. And all the while, he was the exemplar of domesticity—proof that professional achievement need not (must not!) eclipse familial devotion.

Science has seldom had a happier exponent than Robert Traub, whose charm was disarming. To this day, throughout the Third World, even the least of his former technicians remember him with unbridled, often tearful affection. Though a military man, tough "three-gun Traub" never stooped to the language of the gutter; though honored the world over, he never lost the common touch. His humor could leave an audience in stitches, as when he would explain the derivation of the specific epithet *fujigmo* (no, it's not a Japanese surname!), applied to a new chigger by his sardonic associates Cornelius B. Philip and Henry Shepard Fuller (1950, Journal of Parasitology 40: 50–57). One of his favorite recollections was of taking a company of soldiers on an extended field exercise through waist-deep swamps in Southeast Asia. After several days, Traub noticed that the company "ration" of condoms was running low, but his men at least seemed to have overcome their fear of the swamps' purportedly urethraphilous leeches.

Traub often applied the evocative descriptor "Renaissance man" to the luminaries in his life, among them the peerless medical ecologist J. Ralph Audy (1914–1974) of "Imphal Circus" days (Audy's *Red Mites and Typhus,* published in 1968 by the Athlone Press, University of London, may well be the most engaging acarological essay ever written) and, of course, Harry Hoogstraal. But it took one to know one. Traub's interests, like his profession, embraced the world. His erudition was immediately apparent in such spheres as history and classical music, but he was also a connoisseur of fine wines, exotic foods, and East Asian *objets trouvés,* especially those crafted of jade, ivory, or rare woods; of these latter, he amassed invaluable personal collections. Touchingly, he retained a childlike fascination with the films of "Stan" Laurel and Oliver Hardy, the first great comedy team of the "talkies"; a poster of the perennially befuddled "boys" was a fixture in his basement laboratory.

The last decades of Traub's life were virtual excerpts from the Book of Job. Among his afflictions: pernicious diabetes, recurring cancers and, most painful to recall, the loss in 1989 of his gifted daughter Jeannette–all against the backdrop of the oft-untimely passing of his former comradesin-arms. Yet, in the 20 years we knew him, *not once* did we hear him complain. Sustained by Renée, his wife and foil of 57 years, and their accomplished son Roger, Traub's tireless wit prevailed at death's very door, as in an exchange overheard at the National Naval Medical Center, in Bethesda, Maryland. Asked by a Dr. Watson to describe his latest problem, Traub replied: "Alimentary, my dear Watson."

A week before Traub's death, we made a final pilgrimage to his bedside. We found him incoherent, already beyond reach of our farewells. Had he been able to understand us, what could we have said to this man, who all his adult life was contemptuous of his own feelings but ever empathetic with others? Since adolescence, one of us (RGR) has kept on his night table the thoughts of the Roman Emperor and Stoic philosopher Marcus Aurelius Antoninus (A.D. 121–180), as translated by the great John Jackson for Oxford University Press in 1906 and reprinted down to this day. Anticipating by more than a millennium the Florentine triumph that gave us Robert Traub, Antoninus offers these words of parting (XII: 36): "Friend, thou hast been a citizen in this great city, and what matters it whether for five years or three? The law is the same for us all. Where is the hardship, then, if it be no tyrant's stroke, no unjust judge, that sends thee into exile, but the same Nature that brought thee hither, even as the master of the show dismisses the mummer that he put on the stage? . . . For He decrees it shall end, who was once the author of thy existence, and now of thy dissolution . . . . Then depart in peace with all men, for He who bids thee go is at peace with thee."

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TRICHOGRAMMATOIDEA BRASILIENSIS (ASHMEAD)—NEW COMBINATION FOR A SPECIES HISTORICALLY PLACED IN *TRICHOGRAMMA* (HYMENOPTERA: TRICHOGRAMMATIDAE)

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Abstract.—The species *brasiliensis* Ashmead is transferred from *Trichogramma* to *Trichogrammatoidea.* This **new combination** is based on the examination of the remounted holotype.

Key Words. *Trichogramma, Trichogrammatoidea,* taxonomy

In 1904 Ashmead described the species *Pentarthron brasiliensis* from a single female "collected on cotton" in "Bahia", Brazil, in "Mar 83". *Pentarthron* Riley has long been considered a synonym of *Trichogramma* Westwood, and *brasiliense* [1] has always been associated with these nominal genera (Zerova and Fursov 1989). Because the identification of *Trichogramma* species depends largely on male traits, it was pointed out by Pinto and Stouthamer (1994) that the definition of *Trichogramma brasiliense* was unresolved, notwithstanding its continued use in the biological control literature (see De Santis 1989 and below for references). Upon examining the female holotype in the National Museum of Natural History, Smithsonian Institution (Washington, D.C.) (USNM type no. 6596) the question arose as to whether *brasiliense* was correctly placed in *Trichogramma.* Unfortunately, the type was uncleared and poorly mounted, precluding examination of certain fore- and hind wing characters critical for positive generic placement. The specimen was recently remounted and it is now clear that the species is not a *Trichogramma* but instead belongs to the related genus *Trichogrammatoidea* Girault.

Trichogrammatoidea is most easily separated from *Trichogramma* by male genitalia and antennae (Pinto and Stouthamer 1994). However, certain wing features allow either sex to be placed. *Trichogramma* (Fig. 1) is characterized as follows: Forewing (Fig. 1a) marginal vein with three robust and elongate setae on dorsal surface; premarginal vein with two such setae. Two suboval sensilla between the marginal and premarginal veins. RS_1 vein track present behind stigmal vein. Hind wing (Fig. 1b) usually with at least two setal tracks, a middle track which is always complete to the wing apex and a complete or partial posterior track; a third, anterior track is present or absent. In contrast, *Trichogrammatoidea* is characterized as follows: Forewing marginal vein with only two robust and elongate setae on the dorsal surface—the third (apical most) is considerably shorter; premarginal vein with only one seta. One suboval sensillum between marginal and premarginal veins. RS_1 vein track absent. Hind wing with only a middle setal track which is not complete to the wing apex. In addi-

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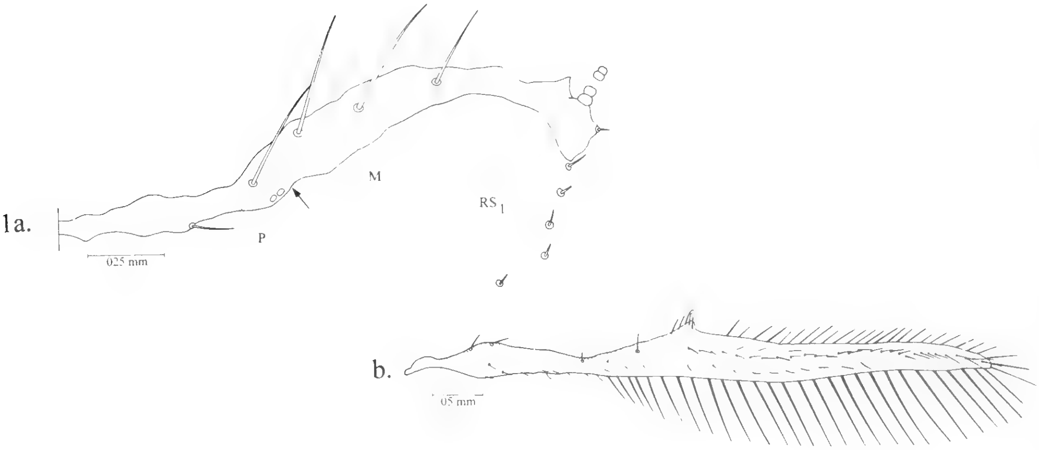
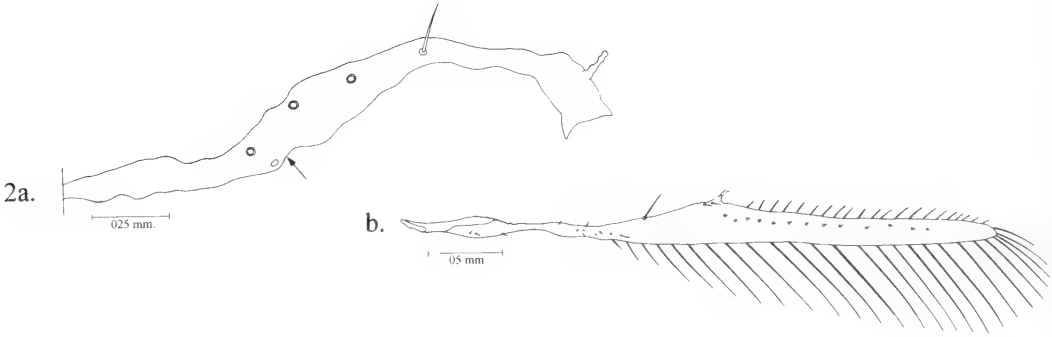
[1] Because this specific name has been associated with generic names of different gender (*Penarthron, Trichogramma,* and *Trichogrammatoidea*), its ending varies in this paper depending on the one it is associated with in discussion.





Figs. 1–2. Wing characteristics. 1, *Trichogramma*: a, Forewing venation, dorsal; b, hind wing, anterior at top. 2, Holotype female of *Trichogrammatoidea brasiliensis*: a, forewing venation, dorsal; b, hind wing, anterior at top. Abbreviations: m = marginal vein; p = premarginal vein; arrow refers to boundary between marginal and premarginal veins.

tion, the forewing is generally broader in *Trichogramma* than in *Trichogrammatoidea* and it has denser setation and shorter fringe setae along its margin.

The holotype of *brasiliensis* is clearly assignable to *Trichogrammatoidea* based on wing characters. During remounting, one forewing and hind wing were placed together under a separate coverslip for optimal viewing and illustration (Fig. 2a, b). In this specimen the RS_1 vein track is absent; only a single setal socket occurs on the premarginal vein, and of the three setae on the marginal vein, the two basal ones are broken but the third, which is present, is relatively short as in *Trichogrammatoidea*. The single suboval sensillum between the premarginal and marginal veins is not visible in the remounted forewing of the type, but it can be seen on the wing which remains attached to the body. Also, as is characteristic of *Trichogrammatoidea* but not *Trichogramma* there is only a single, incomplete setal track on the hind wing of the type. Although a single track occurs in two species of the primitive Lachesis Group of *Trichogramma* (Pinto 1992), it is complete to the wing apex in all species. In addition, the forewing of the type has relatively sparse setation and an elongate setal fringe on its margin, both characteristic of *Trichogrammatoidea.* It is curious that Girault (1911b) upon redescribing this species did not recognize its incorrect generic placement considering that he described *Trichogrammatoidea* earlier in the same year (Girault 1911a) and noted the unique wing characteristics in his redescription (absence of an RS_1 and single setal track in hind wing) which he had incorporated into the definition of the new genus.

Because the holotype of *Trichogrammatoidea brasiliensis* (**new combination**) is a female and in poor condition I am unable to determine with confidence if it is distinct or a synonym of an already described species. It is possible that *Trichogrammatoidea annulata* De Santis, also associated with cotton in Brazil (De Santis 1972), is a synonym of *T. brasiliensis.* I have examined a paratype male and female of *T. annulata* and can find no differences in wing structure or ovipositor length. However, until the South American *Trichogrammatoidea* are better known I suggest continuing to use *T. annulata* as a valid name and treating *T. brasiliensis* as valid but as a *nomen dubium,* i.e. a name not certainly applicable to any known taxon.

The question arises as to what species of *Trichogramma* has/have been misidentified as *brasiliense* in the literature where the name continues to be associated with biological control efforts particularly against pyralid pests of sugarcane (Monje 1995). This is not possible to answer without examining voucher specimens associated with each study. However several years ago I received two cultures identified as *Trichogramma brasiliense,* one from the USDA Laboratory in Beltsville, Maryland, and the other from a *Trichogramma* production center in Torreon, Mexico. Both were *T. fuentesi* Torre, a species generally misidentified as *T. fasciatum* Perkins in the early literature. *Trichogramma fuentesi* was originally described from Cuba but it also occurs in the southeastern United States, Mexico and South America (Pinto et al., 1983). The literature suggests that the name *brasiliense* has been applied to other species as well. For example, Ruiz and Korytkowski (1980) define it as a species which I would consider close to *T. pretiosum* based on their description and illustrations, and Kfir (1982) and others have applied the name to thelytokous populations. The latter usage may stem from Quednau (1961), and Nagaraja and Nagarkatti (1969) who considered *brasiliense* as a thelytokous form of *Trichogramma fasciatum.* The actual species studied by Kfir, Ruiz and Korytkowski, and several other authors, remain undetermined. One of the mysteries of *Trichogramma* taxonomy is how certain common New World species became misidentified as they did and how these misidentifications became so well established in the literature.

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The type of *Trichogrammatoidea brasiliensis* was remounted by Gary Platner. Figures 1 and 2 were prepared by Marina Planoutene. I thank Andrew Polaszek for advice on remounting procedures, and Michael Schauff (Systematic Entomology Laboratory, USDA) for the loan of the type and granting permission to remount it.

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LIFE HISTORY AND DESCRIPTION OF IMMATURE STAGES OF *XENOCHAETA DICHROMATA* SNOW (DIPTERA: TEPHRITIDAE) ON *HIERACIUM ALBIFLORUM* HOOKER IN CENTRAL AND SOUTHERN CALIFORNIA

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Abstract.—*Xenochaeta dichromata* Snow is a nearly monophagous, uni- or bivoltine, synovigenic, seed-feeding fruit fly attacking the flower heads of certain native hawkweeds (*Hieracium* spp., Asteraceae) in western North America. *Xenochaeta aurantiaca* (Doane) is synonymized with *X. dichromata.* The egg, first-third instar larvae, and puparium are described and all but the second instar are illustrated. The third instar is shagreened, i.e., meso-, metathorax, and abdominal segments are covered by minute, dome-shaped verrucae. *Xenochaeta dichromata* differs from other shagreened species in possessing a single row of verruciform sensilla circumscribing each thoracic and abdominal segment. The life cycle is of the aggregative type. Eggs are deposited singly in individual immature flower heads. Each larva consumes the entire contents of a single head, within which it overwinters as a prepuparium. Pupariation occurs in the spring and the newly emerged adults aggregate on the preblossom host plants to mate and oviposit. The possible use of this fly for biological control of hawkweeds in North America and abroad, e.g., in New Zealand, is discussed.

Key Words: Insecta, *Xenochaeta, Hieracium,* hawkweeds, biology, taxonomy of immature stages, florivory, monophagy, reproductive behavior, parasitoids, biological control of weeds

The rearing of a good series of females that key to *Xenochaeta aurantiaca* (Doane) and males that key to *X. dichromata* Snow from the same samples of mature flower heads of *Hieracium albiflorum* Hooker (Asteraceae) in southern California confirm that there is a single, sexually dimorphic species of *Xenochaeta.* These results provided us the opportunity to synonymize these tephritid species and to study the life history and describe the immature stages of this heretofore-little-known, nonfrugivorous fruit fly.

MATERIALS AND METHODS

Our field studies on *X. dichromata* focused mainly on laboratory dissections of flower head samples collected in June or August from different locations on the western slopes of the Sierra Nevada Mountains in central and southern California during 1993–1995: (1) N of Union Valley Reservoir at 1700-m elevation, Eldorado National Forest, Eldorado Co., 19.ix.1993; (2) four sites between 1820 and 2050 m in Mountain Home State Forest, Tulare Co., 3–4.ix.1994; (3) S of Slate Mountain and E of Onion Meadow at 2120 m, Sequoia Nat. Forest (N-section), Tulare Co., 3.ix.1994; (4) S of Sampson Flat at 1210 m, Sequoia Nat. Forest (N-section), Fresno Co., 14.vi.1995. These locations were too far from Riverside to allow field observation of adult behaviors. Samples of immature or mature flower heads of *H. albiflorum* were transported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement. Thirty eggs, five first-, 12 second-, and 18 third-instar larvae, and six puparia dissected from flower heads were preserved in 70% EtOH for scanning electron microscopy (SEM). Additional mature larvae and prepuparia were placed in separate, glass shell vials stoppered with absorbant cotton and held in humidity chambers at room temperature for adult and parasitoid emergence. In 1994, those larvae and prepuparia not pupariating by mid-December were stored in a refrigerator at 2 ± 1°C until August, 1995, before returning them to humidity chambers. Specimens for SEM were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH and two, 1-h immersions in Hexamethlydisilazane (HMDS), mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia were individually caged in 850-ml, clear-plastic, screened-top cages with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. These cagings were used for longevity studies in the insectary of the Department of Entomology, University of California, Riverside, at 25 ± 1°C, and 14/10 (L/D) photoperiod. Virgin male and female flies obtained from emergence vials were paired in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey (Headrick and Goeden 1991, 1994) for direct observations, videorecording, and still-photography of their courtship and copulation behavior.

Plant names used in this paper follow Munz (1974); tephritid names and adult terminology follow Foote et al. (1993). Terminology and telegraphic format used to describe the immature stages follow Goeden et al. (1993, 1994a, b, 1995a, b) and Goeden and Teerink (1996a, b, c; 1997) and our earlier works cited therein. Means ± SE are used throughout this paper. Voucher specimens of *X. dichromata* and its parasitoids reside in the research collections of RDG; preserved specimens of eggs, larvae and puparia are stored in a separate collection of immature Tephritidae maintained by JAT.

RESULTS AND DISCUSSION

TAXONOMY

Adult.—*Xenochaeta dichromata* and *X. aurantiaca* (Doane) were termed "rarely collected" tephritids by Foote et al. (1993). *Xenochaeta dichromata* was described from a single male (therefore holotype) by Snow (1894), and besides records for additional males, only a single female specimen has since been recorded (Foote and Blanc 1979, Foote et al. 1993). *Xenochaeta aurantiaca* was described (as a *Eutreta*) by Doane (1899) and only females heretofore were known. Noting these disparities in sexes recorded, Foote et al. (1993) suggested that ". . . further studies may show these two species to be conspecific." As predicted, only one, sexually dimorphic species is present in California, and these two names are synonyms. Both males of *X. dichromata* (n = 34) and females that keyed to *X. aurantiaca* (n = 29) were consistently and solely reared together from single samples of mature flower heads of *H. albiflorum* collected in August at the above-named study sites, and shortly after their pupariation and emergence as adults, these flies readily mated when placed together in petri dish arenas (n = 5, see below). Therefore, *X. aurantiaca* is hereby synonymized with *X. dichromata,* which has priority.

The wing patterns of both sexes of *X.*

Fig. 1. Egg of *X. dichromata*. pedicel to left.

dichromata were pictured in Foote et al. (1993), the female as *aurantiaca,* and the male wing pattern was figured in Foote and Blanc (1963).

Immature stages.—*Egg.:* Twenty eggs of *X. dichromata* were white, opaque, smooth; with an elongate-ellipsoidal body, 0.44 ± 0.002 (range, 0.41–0.46) mm long, 0.17 ± 0.002 (range, 0.17–0.19) mm wide, smoothly rounded at tapered posterior end, and with a peg-like anterior pedicel, 0.02 mm long (Fig. 1).

Third instar: Oblong-ovoid, tapering anteriorly, truncated posteriorly, shagreened (Fig. 2A); gnathocephalon conical, smooth, few rugose pads laterally (Fig. 2B); dorsal sensory organ a single, dome-shaped papilla (Fig. 2B-1, C-1); anterior sensory lobe (Fig. 2B-2, C) bears terminal sensory organ (Fig. 2C-2), pit sensory organ (Fig. 2C-3), lateral sensory organ (Fig. 2C-4) and supralateral sensory organ (Fig. 2C-5); stomal sense organ, a distinct lobe invested with sensoria ventrolaterad of anterior sensory lobe (Fig. 2B-3, D-1); mouth hooks tridentate (Fig. 2B-4, D-2); median oral lobe tapers anteriorly, attached to labial lobe (Fig. 2D-3); prothorax circumscribed anteriorly with minute acanthae, single row of verruciform sensilla circumscribe each thoracic and abdominal segment; anterior thoracic spiracles with 4–6 raised papillae (Fig. 2E); meso- and metathoracic lateral spiracular complexes consist of an open spiracle and a single verruciform sensillum; abdominal lateral spiracular complexes consist of an open spiracle (Fig. 2F-1) and two verruciform sensilla (Fig. 2F-2); posterior spiracular plates consist of three ovoid rimae, ca. 0.03 mm in length (Fig. 2G-1), and four interspiracular processes, longest measuring 0.01 mm (Fig. 2G-2); verruciform sensilla circumscribe caudal segment (Fig. 2G-3); compound sensilla each consist of two verruciform sensilla, one with a central papilla (Fig. 2G-4, H).

Norrbom et al. (1997) placed *Xenochaeta* in the new Tribe Noeetini along with *Acidogona* and *Jamesomyia.* Benjamin (1934) briefly described the immature stages of *Acidogona melanura* Loew, and the general habitus of the egg, mature larva, and puparium of this species do resemble *X. dichromata.* However, *X. dichromata* is the only species in the tribe for which the immature stages are described in detail.

Xenochaeta was placed in the Tribe Eutretini by Foote et al. (1993). Other genera and species in this tribe for which the immature stages have been described in similar detail include *Eutreta diana* (Osten Sacken) (Steck and Wharton 1986; Goeden 1990a, b) and *Paracantha gentilis* Hering (Headrick and Goeden 1990a). *Xenochaeta dichromata* differs from these two species in having a shagreened mature larva. Goeden (1990a) described *E. diana* (Osten Sacken) first instar as ringed with verrucae on abdominal segments II–V. However, the verrucae are absent or nearly so on the second and third instars (Steck and Wharton 1986, Goeden 1990a). Two species from other tribes in which the mature larva also are shagreened are *Tomoplagia cressoni* Aczel (Tribe Acrotaeniini) and *Valentibulla californica* (Coquillett) (Tribe Dithrycini) (Goeden and Headrick 1991, Goeden et al. 1995b, Foote et al. 1993). The latter of these two species most closely resembles *X. dichromata,* but lacks the verruciform sensilla that circumscribe the thoracic and abdominal segments in *X. dichromata.* Also, the posterior two-thirds of the prothorax is

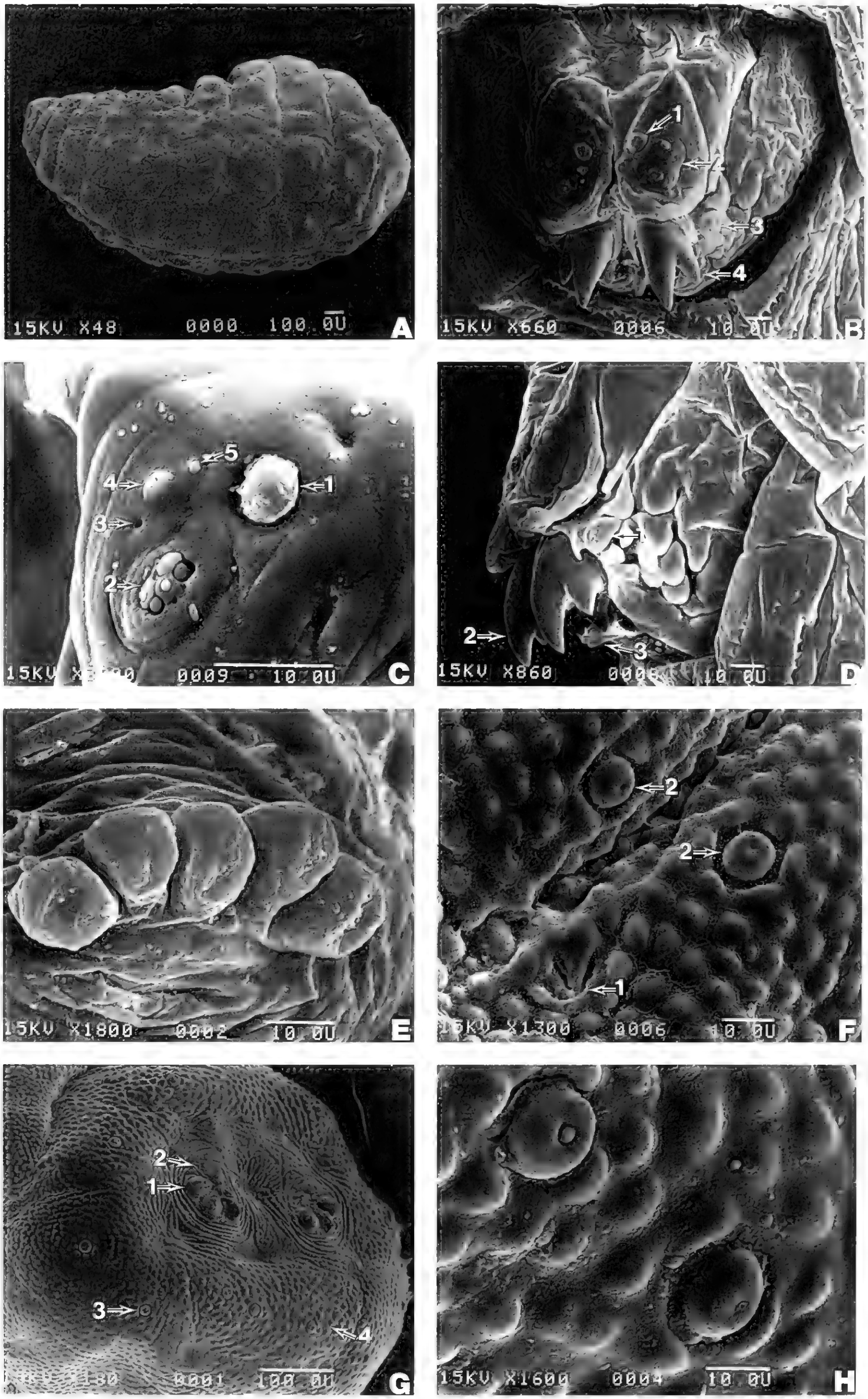

Fig. 2. Third instar of *X. dichromata.* (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—anterior sensory lobe, 3—stomal sense organ, 4—mouth hooks; (C) anterior sensory lobe, 1—dorsal sensory organ, 2—terminal sensory organ, 3—pit sensory organ, 4—lateral sensory organ, 5—supralateral sensory organ; (D) gnathocephalon lateral view, 1—stomal sense organ, 2—mouth hooks, 3—median oral lobe; (E) anterior thoracic spiracle; (F) fourth abdominal lateral spiracular complex, 1—spiracle, 2—ver-

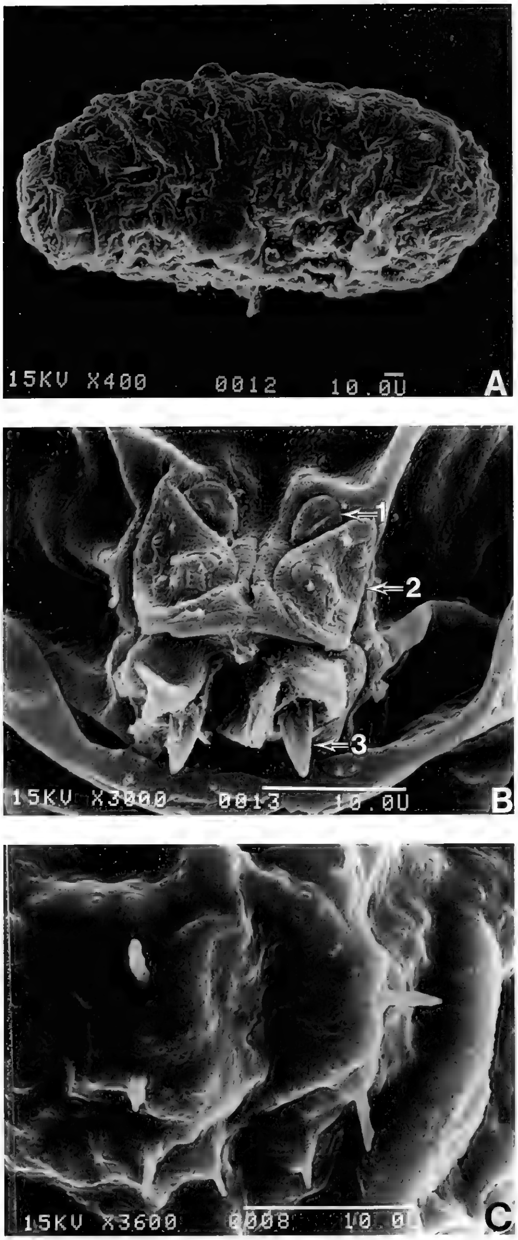

Fig. 3. First instar of *X. dichromata.* (A) habitus, anterior to left; (B) gnathocephalon, anterior view, 1—dorsal sensory organ, 2—anterior sensory lobe, 3—mouth hooks; (C) caudal segment, posterior spiracular plates.

shagreened in *V. californica,* the mouth hooks are bidentate, and the abdominal lateral spiracular complex consists of an open spiracle and a single sensillum (Goeden et al. 1995b).

Second instar: Elongate-ovoidal, rounded anteriorly and posteriorly, shagreened; gnathocephalon conical, few rugose pads laterad of stomal sense organ; dorsal sensory organ composed of a single papilla; anterior sensory lobe bears all four sensory organs; stomal sense organs distinct, ventrolaterad of anterior sensory lobe; mouth hooks bidentate; median oral lobe tapering anteriorly; thoracic segments smooth, single row of verruciform sensilla circumscribe thoracic and abdominal segments; anterior thoracic spiracles and lateral spiracular complex were not observed; posterior spiracular plates bear three ovoid rimae, ca. 0.018 mm in length and four interspiracular processes, longest measuring 0.006 mm; compound sensilla were not observed.

The second instar differs from the mature larva in that the dome-shape verrucae are smaller and restricted to the dorsad and intersegmental lines of the abdominal segments, and the mouth hooks are bidentate.

First instar: Elongate-ellipsoidal, minute verrucae circumscribing abdominal segments (Fig. 3A); gnathocephalon conical, smooth, lacking rugose pads (Fig. 3B); dorsal sensory organ consists of a dome-shaped papilla (Fig. 3B-1); anterior sensory lobe bears all four sensory organs (Fig. 3B-2); stomal sense organs indistinct; mouth hooks bidentate (Fig. 3B-3); median oral lobe not observed; prothorax with minute acanthae ventrally; posterior spiracular plates contiguous, bear two ovoid rimae and four interspiracular processes (Fig. 3C).

The first instar has fewer, smaller, dome-shaped verrucae than later instars. The first instar habitus is more ellipsoidal in shape,

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ruciform sensilla; (G) caudal segment, 1—rima, 2—interspiracular process, 3—verruciform sensillum, 4—compound sensillum; (H) posterior compound sensillum, verruciform sensillum with central papilla.

not as tapered anteriorly. Sensory structures such as the stomal sense organ are not as well-defined in the first instar as they are in the later instars. The verruciform sensilla circumscribing the thoracic and abdominal segments in the later instars were not observed.

Puparium: Dark brown, elongate-ellipsoidal, tapering anteriorly, rounded posteriorly, shagreened (Fig. 4A); anterior end bears invagination scar (Fig. 4B-1) and anterior thoracic spiracles (Fig. 4B-2); caudal segment bears posterior spiracular plates (Fig. 4C-1), compound sensilla (Fig. 4C-2), and verruciform sensilla (Fig. 4C-3). Twenty-five puparia of *X. dichromata* averaged 3.19 ± 0.05 (range, 2.85–3.60) mm in length; 1.61 ± 0.03 (range, 1.48–1.79) mm in width.

DISTRIBUTION AND HOSTS

The distribution of *X. dichromata* in North America north of Mexico was mapped by Foote et al. (1993) (also as *X. aurantiaca*) to include locations in British Columbia, California, Montana, Oregon, Utah, and Washington. Linda Wilson and J. McCaffrey (in litt. 1995, 1996) also have reared *X. dichromata* from *Hieracium albiflorum* and the *H. scouleri* Hooker complex in Idaho, but not from any of the introduced hawkweeds, e.g., *H. pratense* Tausch. Between 1987 and 1994, eight, 1-liter samples of mature flower heads of *H. albiflorum* collected by RDG (unpublished data) at locations in El Dorado, Fresno, Kern, Madera, Mono, and Trinity counties different from our above-named study sites all failed to yield *X. dichromata*. Similarly, six samples of mature flower heads of *H. horridum* Fries collected by RDG (unpublished data) from 1987–1993 yielded no *X. dichromata*. Only one other host-plant has been reported, *H. cynoglossoides* Arvet-Touvet (Novak et al. 1967, Foote et al. 1993), indicating that *X. dichromata* is nearly monophagous (one host genus) in flower heads of certain species of *Hieracium*, but does not occur in all parts of its host-plants' geographic ranges. Dodson and George (1986) demonstrated convincingly that the gall-forming tephritid flies *Aciurina bigeloviae* (Cockerell) and *A. trixa* Curran

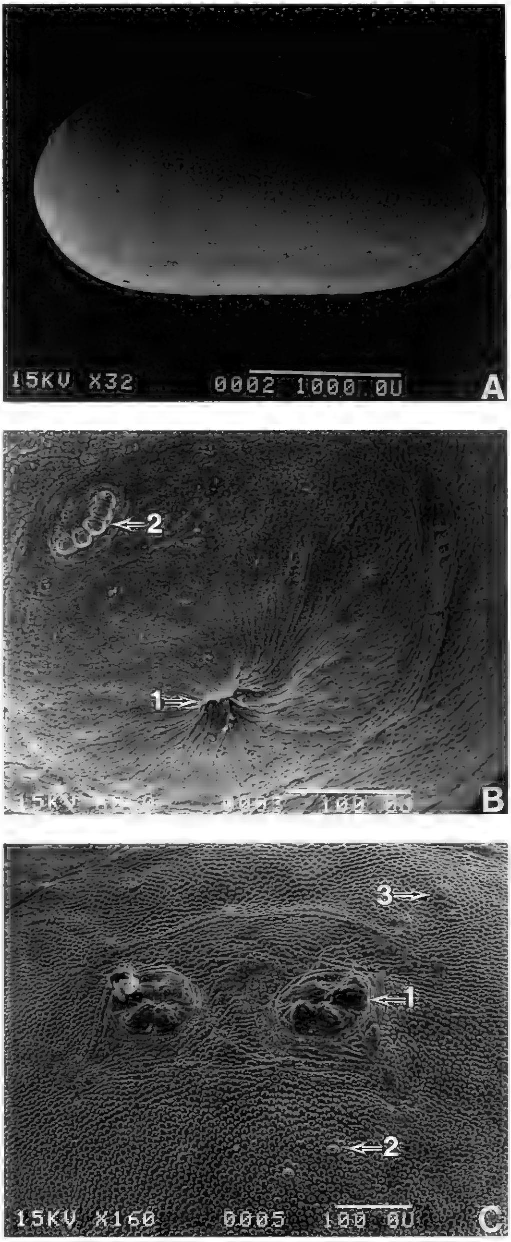

Fig. 4. Puparium of *X. dichromata*. (A) habitus, anterior to right; (B) anterior end, 1—invagination scar, 2—anterior thoracic spiracle; (C) caudal segment, 1—posterior spiracular plates, 2—compound sensilla, 3—verruciform sensillum.

are less widely distributed than their host plants within four southwestern States.

BIOLOGY

Egg.—Only two (6%) of 34 preblossom flower heads contained two eggs each, the rest of these closed, immature heads each contained a single egg (Fig. 5A, B). Immature heads with eggs averaged 1.07 ± 0.04 (range, 0.64–1.50) mm in diameter. Eleven (32%) of 34 eggs examined were oriented with the long axis parallel to the long axes of the tiny, immature florets (Fig. 5A), 14 eggs (41%) were inserted nearly perpendicular to the long-axes (Fig. 5B) and nine eggs (26%) were inserted at angles of 45–60°. Only one (9%) of the 11 eggs inserted parallel to the florets (pedicel-last like all tephritid eggs examined by us to date, Fig. 5A), penetrated an ovule or floral tube; whereas 14 (60%) of the 23 eggs oviposited at an angle to the florets penetrated an ovule or floral tube after the aculeus had penetrated one or more phyllaries during oviposition. Ten eggs rested atop the immature florets and parallel to the receptacle in the small cavity formed by the overlapping phyllaries (Fig. 5B).

Larva.—Newly eclosed first instars (Fig. 5C) fed parallel to the receptacle on ovules or floral tubes inside closed heads that averaged 1.36 ± 0.08 (range, 1.14–1.71; n = 7) mm in diameter. Six first instars each damaged an average of 2.5 ± 0.7 (range, 1–5) florets. The second instar (Fig. 5D) fed centrally, well above and parallel to the receptacle, consuming the upper parts of the ovules and the bases of the floral tubes within a circle of intact, outer florets (Fig. 5D). Eleven feeding chambers of second instars within closed, immature, flower heads averaging 2.47 ± 0.14 (range, 1.71–3.13) mm in diameter measured 1.32 ± 0.12 (range, 0.85–1.71) mm by 1.03 ± 0.13 (range, 0.57–1.42) mm (Fig. 5D).

The third instar continued to enlarge the feeding chamber, eventually destroying all ovules and floral tubes within the infested heads (Fig. 5E, F). Thirty uninfested mature heads of *H. albiflorum* produced an average of 19 ± 0.6 (range, 15–28) achenes. Usually, only one larva developed to maturity in each of 132 infested heads examined (Fig. 5E). Once the third instar consumed the florets, it deeply scored the receptacle and supplemented its diet with sap that collected in the feeding depression, as reported with several, but not all, florivorous, California Tephritidae that we have studied (Goeden 1988, Headrick and Goeden 1990a, b, Goeden and Headrick 1991, 1992, Goeden et al. 1993, 1995a, Headrick et al. 1996). The infested heads never opened or showed any protruding pappus apically and were more conical in shape than the ellipsoidal, uninfested heads (Fig. 5F). One hundred heads containing unparasitized mature larvae or prepuparia averaged 3.26 ± 0.05 (range, 2.00–4.57) mm in diameter (Fig. 5F). The feeding cavities of these fully grown, third instars measured 3.91 ± 0.05 (range, 1.71–5.13) mm in length by 2.23 ± 0.03 (range, 1.42–2.85) mm in width (Fig. 5E). The walls of these chambers were stiffened by a dried, hardened mixture of floret fragments, feces, and dried sap that coated and glued together the inner walls of the phyllaries (Fig. 5E).

Pupa.—Fully grown larvae ceased feeding, contracted their bodies, invaginated their mouthparts, and darkened ventrally and posteriorly to become prepuparia. Most prepuparia entered diapause and overwintered in the dried heads, but eight of 33 (25%) held in moist chambers in the laboratory in 1994 reversed their position 180° within excised flower heads, pupariated (Fig. 5G), and emerged as adults (Fig. 5H, I).

Adult.—Foote and Blanc (1979) remarked that the entire genus *Xenochaeta* at that time was represented in U.S. collections by a total of only 10–12 specimens. After 3 years of study, our reared specimens from California number 63, of which 34 (54%) are males. Adults were long-lived under insectary conditions, as 13 males averaged 48 ± 7 (range, 15–97) days, and 12

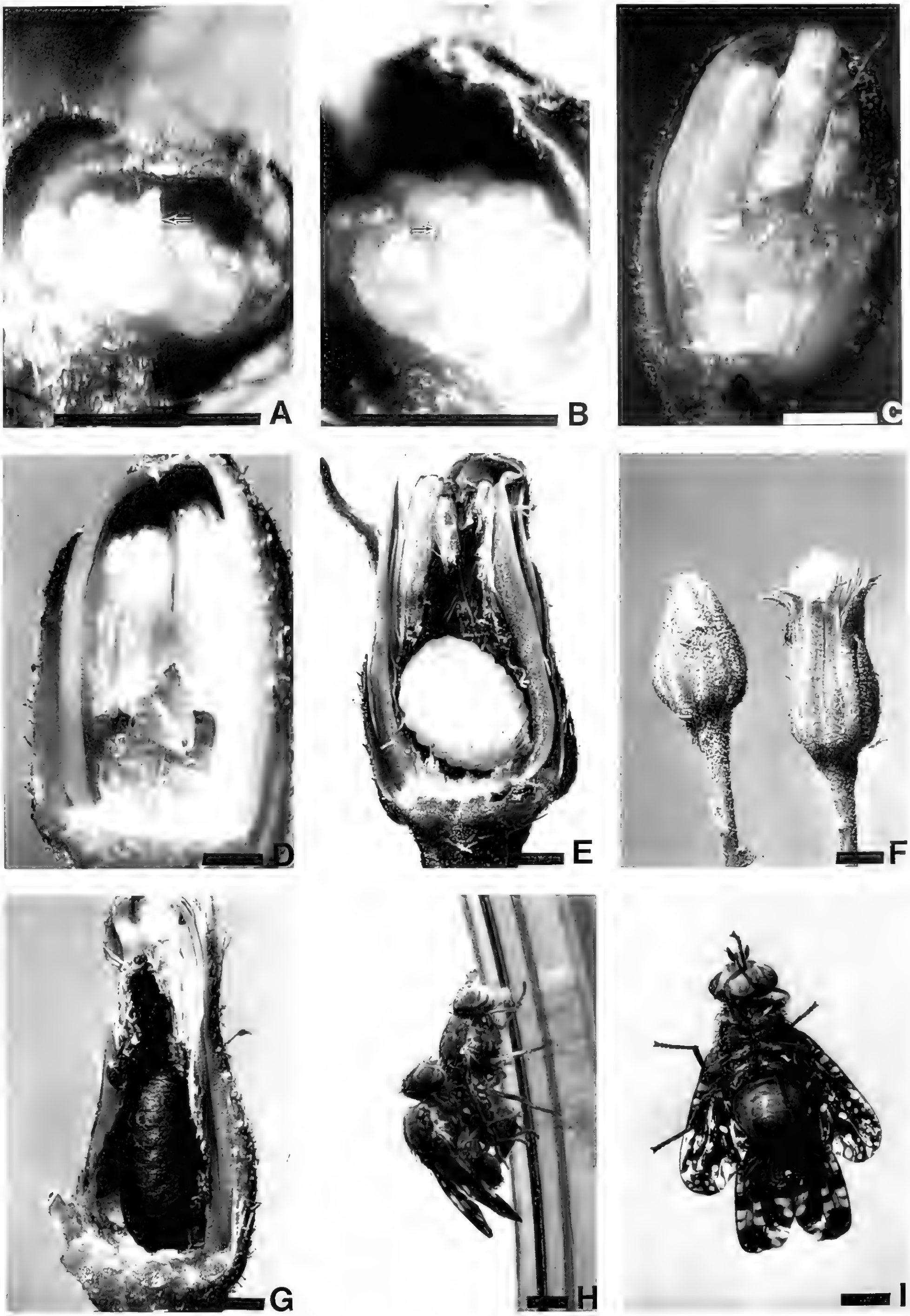

Fig. 5. Life stages of *X. dichromata* on *Hieracium albiflorum*. (A) egg (arrow) inserted between florets of immature, preblossom flower head; (B) egg (arrow) resting atop florets parallel to receptacle; (C) first instar feeding at base of floral tube; (D) second instar feeding on ovules and floral tube bases; (E) fully grown third instar in feeding chamber; (F) infested flower head containing third instar (left), uninfested head right; (G) Puparium in head; (H) mating pair, lateral view; (I) mating pair, ventral view. Lines = 1 mm.

females averaged 31 ± 5 (range, 8–65) days. Males (n = 5) readily mated when 3 to 18 days old; females (n = 5), when 3 to 17 days old (Fig. 5H, I). A 20-day-old female contained a full compliment of full-size ova, but otherwise ovigenesis and oviposition were not studied in the laboratory or field, nor were free-living adults ever observed or collected.

As observed with adults of *Eutreta diana* by Goeden (1990a, unpublished data) and *Paracantha gentilis* (Headrick and Goeden 1990a, 1995), adults characteristically rested or walked with their wings arched and parted and exhibited abdominal flexures. Another behavior exhibited by males of *X. dichromata* and *E. angusta* Banks (Headrick and Goeden 1995) was side-stepping displays by males when facing and tracking females in arenas. Wing displays by males and females of *X. dichromata* most commonly were synchronous supinations, and less commonly, slower paced, asynchronous wing supinations by males, or wing lofting of 20° embellished with rapid wing vibration, when tracking females. No abdominal pleural expansion by males was observed, and also unlike *P. gentilis* (Headrick and Goeden 1990a, 1995), initiation and termination of mating was simple and direct, involving little or no pre- or post-copulatory behaviors. Copulatory postures exhibited by both sexes were similar to those generally described for other nonfrugivorous tephritids (Fig. 5H, I). Five pairs mated 11 times on successive days for an average duration of 89 ± 14 (range, 22–145) min.

Seasonal history.—Like *Neaspilota viridescens* Quisenberry (Goeden and Headrick 1992), *Urophora timberlakei* Blanc and Foote (Goeden and Teerink 1995a), and other *Neaspilota* and *Urophora* spp. studied in southern California (our unpublished data), the life cycle of *X. dichromata* follows the aggregative pattern in which overwintering is largely by prepuparia in dead flower heads. These overwintered prepuparia pupariate and emerge as adults the next spring or summer, or overwintering is by long-lived adults in reproductive diapause, that return to and aggregate on preblossom host plants during the following spring and summer to mate and reproduce (Headrick and Goeden 1995). It is also possible that adults of *X. dichromata* that emerge from flower heads in late summer (August) produce a second generation in late-forming, preblossom flower heads of *Hieracium albiflorum,* or different, as yet undetermined, alternate host plant(s), at higher elevations (Goeden and Headrick 1992; Goeden et al. 1995a).

Natural enemies.—Two species of solitary, hymenopterous, parasitoids were reared from puparia of *X. dichromata* in flower heads of *H. albiflorum* and were identified for us as *Pteromalus* sp. (Pteromalidae) and Braconinae sp. (Braconidae). The former species was the more common parasitoid.

Biological control.—In the northwestern United States, three species of *Hieracium* native to Eurasia are weeds of forests, pastures, meadows, and wetlands: mouseear hawkweed (*H. pilosella* L.), orange hawkweed (*H. aurantiacum* L.), and yellow hawkweed (*H. pratense* Tausch). In addition, two weedy native species, narrowleaf hawkweed (*H. umbellatum* L.) and Canadian hawkweed (*H. canadense* Michaux) are found in the Northwest (Birdsall and Quimby 1996). In New Zealand, four introduced species of European origins (including *H. pilosella*) are invasive weeds affecting livestock production and native-plant and soil conservation in grasslands (Syrett and Sárospataki 1993). Holm et al. (1979) listed Canada, Russia, and Finland as additional countries in which hawkweeds are problems. A consortium reportedly has been formed to identify and assess candidate agents for biological control of hawkweeds. This group includes representatives from the U.S. Department of Agriculture, Agricultural Research Service; University of Idaho; Agriculture Canada; the International Institute of Biological Control, Switzerland and United Kingdom; the Commonwealth Scientific and Industrial Research Organization, Australia; and Landcare Research New Zealand Limited (Birdsall and Quimby 1996). The final draft of the present report was given to colleagues representing selected member organizations in this consortium for their possible interest in *X. dichromata* as a candidate biological control agent, especially for export to New Zealand, if it will attack and reproduce on one or more of the weedy species introduced there. As noted above, this nearly monophagous fruit fly attacks only some native North American species of *Hieracium,* and apparently, has not been reared from any introduced weedy species. Consequently, it may prove too host specific for domestic redistribution and augmentation, or otherwise unsuitable for export, like other native North American insects found attacking native and introduced weeds (cf., Goeden and Kok 1986, Goeden and Teerink 1993, Goeden and Palmer 1995).

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A NEW SPECIES OF *MEGASTIGMUS* DALMAN (HYMENOPTERA: TORYMIDAE) REARED FROM SEEDS OF ATLANTIC WHITE CEDAR (CUPRESSACEAE), WITH NOTES ON INFESTATION RATES

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Abstract.—A new species, **Megastigmus thyoides Kamijo** (Hymenoptera: Torymidae), which emerged from seeds of Atlantic white cedar, *Chamaecyparis thyoides* (L.) B.S.P., collected in eastern United States is described and illustrated. This is the first record of this genus exploiting seeds of Cupressaceae in the Nearctic region. An average of 7% of the seeds collected from five sites in North Carolina were infested with this seed chalcid.

Key Words: Hymenoptera, Torymidae, *Megastigmus thyoides,* new species, *Chamaecyparis thyoides,* seed chalcid

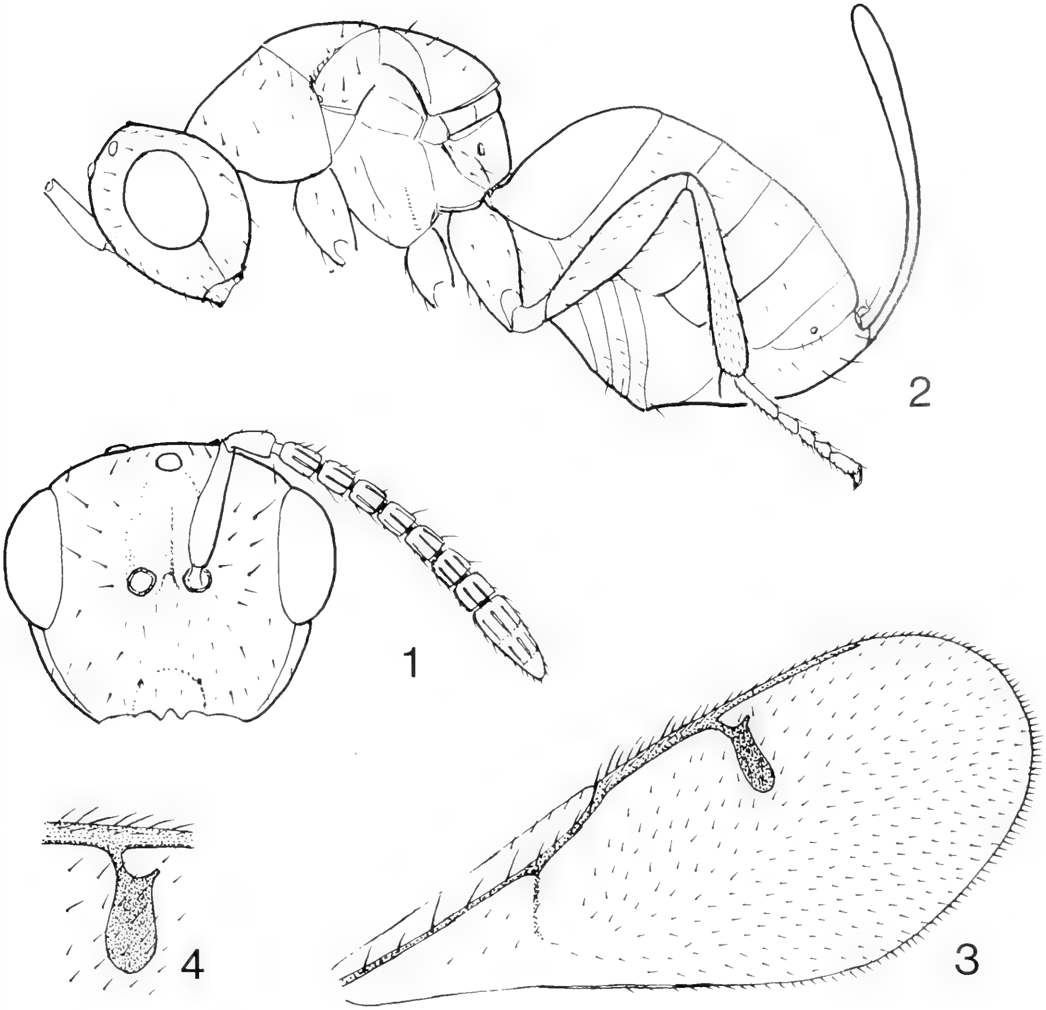
For several tree species, insects often represent the most important source of seed mortality during the pre-dispersal phase of seed development (i.e., while still developing on the tree). Most insects exploiting the seed cones of commercially important conifers native to North America have already been identified, as surveys over the past 30 years have focused almost entirely on these trees (Miller et al. 1995, Turgeon et al. 1994). Conversely, knowledge of the entomofauna of native conifers that are of lesser economic importance is scarce. During a survey initiated in 1994 to address some of these knowledge gaps, we discovered specimens of an undescribed species of *Megastigmus* Dalman (Hymenoptera: Torymidae) feeding in seeds of Atlantic white cedar, *Chamaecyparis thyoides* (L.) B.S.P. (Cupressaceae). This species is described below and the rates of seed infestation observed are presented.

There are approximately 100 described species of *Megastigmus* worldwide (Bouček 1988, Xu and He 1995). Most species are phytophagous (Roux and Roques 1996); exploiting seeds of either coniferous or deciduous trees or shrubs (Milliron 1949; Bouček 1988). Conifers from the Pinaceae, Cupressaceae and Taxodiaceae families are exploited by at least 45 species of *Megastigmus* (Yates 1986, Turgeon et al. 1994, Xu and He 1995, A. Roques, personal communication).

Morphological terminology and measurements generally follow those of Bouček (1988). The following abbreviations are used throughout the text: F1–F7 = funicular segments 1–7; T1–T7 = tergites 1–7.

Megastigmus thyoides Kamijo,
New Species
(Figs. 1–4)

Female.—Body length 1.4 to 1.7 mm. Body brownish yellow: T1–T4 each with vague dark band. Antenna with pedicellus and flagellum dark brown. Wings subhya-



Figs. 1–4. *Megastigmus thyoides*. 1, Frontal view of female head and antenna. 2, Lateral view of female. 3, Forewing of female. 4, Stigmal vein of forewing of male.

line; veins including basal vein dark brown. Ovipositor sheath blackish.

Head in dorsal view about 1.6 times as broad as long, with occiput weakly emarginate and temples roundly converging. POL nearly 1.6 times OOL. Vertex weakly strigate; ocellar area, frons and lower face strigate-reticulate. Head covered with sparse, black setae, but most setae on lower face whitish. Eyes separated by 1.6 times their height. Malar space slightly longer than half height of eye. Antennal scrobes almost reaching median ocellus; toruli situated exactly in middle of height of head (Fig. 1). Scape reaching level of vertex; combined length of pedicellus and flagellum 1.2 times breath of head; flagellum weakly clavate; anellus slightly transverse to quadrate; F1 nearly as long as pedicellus; F7 quadrate to slightly transverse; sensilla disposed in 1 row on each funicle segment.

Thorax strongly arched in lateral view (Fig. 2), 1.5 to 1.6 times as long as broad in dorsal view. Pronotum nearly 1.6 times as broad as long, strigate-reticulate. Mesoscutum a little longer than pronotum; mid-lobe with distinct, raised reticulation, and 2 or 3 black setae present on each side; scapulae reticulate. Scutellum as long as broad, sculptured like mesoscutal mid-lobe, with 3 or 4 setae on each side; frenum more coarsely reticulate, with frenal line indistinct, almost straight. Propodeum with strongly raised reticulation, sometimes median carina present; callus with 3 or 4 whitish setae. Prepectus with oblique carina rather indistinct. Mesepisternum and mesepimeron densely reticulate.

Forewing: marginal vein slightly shorter than postmarginal; stigmal vein a little longer than half length of marginal, with stigma slender, basal cell with 1 or 2 apical setae, open in basal half; basal vein distinctly pigmented; speculum rather large, closed below (Fig. 3).

Gaster a little longer than thorax; hind margins of T1 and T2 barely incised medially. Ovipositor sheath weakly clavate, about as long as thorax or 1.6 to 1.9 times as long as hind tibia (Fig. 2).

Male.—Differs from female as follows. Body length 1.4 to 1.9 mm. Ocellar area usually dark brown; scutellum posteriorly, metanotum and propodeum sometimes darker; gaster with T1–T5 more extensively dark brown. Head in dorsal view 1.6 to 1.7 times as broad as long; combined length of pedicellus and flagellum nearly 1.4 times breadth of head; flagellum filiform, covered with denser setae; F7 quadrate to slightly longer than broad. Thorax more slender, sometimes nearly 1.8 times as long as broad. Mid-lobe of mesoscutum with 3 to 5 setae on each side. Scutellum slightly longer than broad. Forewing with stigma slightly broader; basal cell with 2 or 4 setae, open basally (Fig. 4). Gaster much longer than thorax.

Types.—Holotype ♀, Dare County, North Carolina, USA, *ex* seed of *Chamaecyparis thyoides* collected in 1994, deposited in Canadian National Collection of Insects (CNCI). Paratypes: 14 ♀, 15 ♂, with same rearing data as holotype. 2 ♂ and 2 ♀ paratypes deposited in the National Museum of Natural History, Smithsonian Institution, and in the personal collection of JJT at the Canadian Forest Service-Great Lakes Forestry Centre, Sault Ste. Marie, Ontario, Canada. Another pair is at Hokkaido University, Sapporo, Japan. The remainder of the paratypes are deposited in the CNCI.

Distribution.—Dare, Wayne and Perquimins Counties, North Carolina, U.S.A.

Host.—Seeds of Atlantic white cedar, *Chamaecyparis thyoides* (L.) B.S.P. (Cupressaceae).

Discussion.—*Megastigmus thyoides* Kamijo is the first record of this genus exploiting seeds of Cupressaceae in the Nearctic Region. In the Palaearctic Region however, seeds of Cupressaceae are host to thirteen species of *Megastigmus.* Eight of these thirteen species infest seeds of *Juniperus* spp. Seeds of *Cupressus* spp., *Chamaecyparis* spp. and *Thujopsis* spp. are exploited by three, one and one species of seed chalcid, respectively (Zerova and Seryogina 1994, Xu and He 1995). There is also a record of this genus exploiting seeds of Cupressaceae in the Oriental Region, where *M. cupressi* Mathur infests seeds of *Cupressus torulosa* Don. (Mathur 1955).

Megastigmus thyoides Kamijo is characterized by the reticulate sculpture on the head and thorax, the elongate stigma, the short ovipositor, and the strongly arched thorax in longitudinal axis. This species appears closely related to two phytophagous species from Japan, *M. chamaecyparidis* Kamijo and *M. thuyopsis* Yano that exploit seeds of *Chamaecyparis obtusa* (Sieb. and Zucc.) Endl. and *Thujopsis dolabrata* Sieb. and Zucc. (Cupressaceae), respectively (Kamijo 1962). All three species have a row of sensilla on all funicular segments, a brownish-yellow body, and the pronotum, mesoscutum and scutellum weakly sculptured with a small number of black bristles. However, unlike *M. thyoides,* the two Japanese species have the head, pronotum and mesoscutum weakly strigate, a weakly arched thorax, nearly 1.9 times as long as broad in dorsal view, a stigma less slender, and ovipositor sheaths 1.7 times as long as thorax in *M. chamaecyparidis,* and 1.3 times as long in *M. thuyopsis.*

Megastigmus thyoides also resembles the Nearctic species *M. hoffmeyeri* Walley, which feeds in seeds of *Tsuga canadensis* (L.) Carr. (Pinaceae) (Milliron 1949) and the Japanese *M. tsugaphilus* Kamijo (Kamijo 1962). Both *M. thyoides* and *M. hoffmeyeri* have a body entirely brownish yellow and an elongate stigma, but according to the redescription given by Milliron (1949), *M. hoffmeyeri* has a longer ovipositor, pronotum and mesoscutum rugulose, and distal funicle segments longer than *M. thyoides. Megastigmus tsugaphilus* also has a brownish body and a strongly arched thorax which resembles that of *M. thyoides.* In *M. tsugaphilus,* however, besides the long ovipositor and the strigate sculpture on the head and thorax, the funicular segments have two rows of sensilla, the basal cell of the forewing has many setae, and the mid-lobe of scutellum usually has five setae on each side (Kamijo 1962).

The most recent key for the Nearctic species of *Megastigmus* is that by Milliron (1949). Females of *M. thyoides* key best at a slightly modified (**in bold**) couplet 3 of Milliron's key.

3. Pronotum **weakly arched** above and without sharp transverse rugae; **mid-lobe of** mesoscutum with fine, reticulate sculpture; stigma narrow-elongate, **pointed or rounded on lower margin**; small species (1.2 to 2.2 mm.) 3a
– Pronotum **more strongly arched** and usually with at least one distinct transverse ruga; **mid-lobe of mesoscutum transversely rugulose or sometimes shingled**; stigma more or less oval or circular 5
3a. Stigma narrow-elongate oval with lower margin rounded (Fig. 3); setae on head and thoracic dorsum black . . . . *thyoides* Kamijo
– Stigma surrounded by cloud or somewhat triangular, with lower margin pointed (Milliron 1949: Figs. 7, 9); setae on head and thoracic dorsum pale 4

Males of *M. thyoides* key out at couplet 43. Some characters of *M. thyoides* used in the following modified couplet are not included in our description (e.g., length of hind legs).

43. Hind tarsus distinctly greater than two-thirds of the hind tibia; proximal tarsal segments rather long, the dorsal measurement of the first about 1 ⅔ that of the second 43a
– Hind tarsus nearer to two-thirds as long as the hind tibia; proximal segments of hind tarsus comparatively shorter than above . . 44
43a. Pronotum nearly as long as wide; mesoscutum and scutellum transversely rugulose; head and thorax brownish yellow with blackish markings . . . . *rafni* Hoffmeyer
– Pronotum distinctly wider than long; mesoscutum and scutellum densely reticulate; head and thorax entirely brownish yellow . . . . *thyoides* Kamijo

Etymology.—This species is named after its host, *C. thyoides.*

Biology.—This species is a phytophagous insect developing in seeds of its host. Most species of this genus developing in conifer seeds have a univoltine life cycle, overwintering as a 5th instar in seed on the ground (Hedlin et al. 1980). Thus far, only *M. spermotrophus* Wachtl has been shown to oviposit and develop in unfertilized seeds (Niwa and Overhulser 1992, Rappaport et al. 1993). Whether this species also develops in unfertilized seeds of *C. thyoides* will be investigated together with its potential for prolonged diapause, a mechanism used by several species of this genus to compensate for annual fluctuations in cone abundance (Roux 1995).

Seed cones of *C. thyoides* were collected in late-October early-November 1994 from various sites (each identified with a different seed lot number) in North Carolina (Table 1). Cones were dried at room temperature and the seeds extracted. A subsample of seeds from each lot was spread as uniformly as possible on a sheet of Kodak Industrex 620 X-ray paper and irradiated with a Hewlett Packard Faxitron 43805N X-Ray system for 30 sec at 15 Kv and 3 mA. The exposed paper was developed using a model P-1 Ko-

Table 1. Quality of *C. thyoides* seeds collected in North Carolina together with infestation rates by *M. thyoides.*

Collection Site	County	Seed Lot Number	Type of Stand	Filled (%)	Empty (%)	Infested by *M. thyoides*
Sasser Tract (Goldsboro)	Wayne	WC-NC 94-6A	5-y-old tree farm	37.7	58.5	3.8
Sasser Tract (Goldsboro)	Wayne	WC-NC 94-6B	5-y-old tree farm	28.0	67.4	4.6
Milltown Road (East Lane)	Dare	WCNC 94-7	Natural stand	7.6	81.2	11.2
D-7 (Elizabeth City)	Perquimins	WCNC 94-8	Plantation	35.7	63.2	1.1
Dare Bomb Range (Stumpy Point)	Dare	WCNC 94-9	Stand-logged	10.0	75.0	15.0
Average				23.8	69.0	7.2

dak Industrex Instant Processor. On each radiograph an acetate overlay with 1 cm grid intervals and coordinates from a random number table were used to locate the centre points for 10, non-overlapping circles (diam. of 3 cm). A 10x hand lens was used to examine the radiographic images and determine for each seed lot the numbers of filled, empty and chalcid-infested seeds within each circle.

The proportions of filled, empty and chalcid-infested seeds varied substantially among seed lots (Table 1). On average, almost 70% of the seeds from each seed lot were empty. The true impact, as defined by Rappaport et al. (1993), of *M. thyoides* could not be assessed because the number of sound seeds in chalcid-excluded cones could not be determined. Nonetheless, seed infestation rates by *M. thyoides* appear relatively low, never exceeding 15% in a seed lot. These rates are similar to those reported for other species of *Megastigmus* exploiting conifers in their native range (Hedlin et al. 1980, Roques 1983).

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SHOOT OR STAB? MORPHOLOGICAL EVIDENCE ON THE UNRESOLVED OVIPOSITION TECHNIQUE IN *STYLOGASTER* MACQUART (DIPTERA: CONOPIDAE), INCLUDING DISCUSSION OF BEHAVIORAL OBSERVATIONS

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Abstract.—Behavioral observations on the oviposition behavior of *Stylogaster* are reviewed in combination with data on the egg morphology, egg placement, and the female postabdomen. The internal female reproductive tract of *S. stylosa* Townsend is described. While some behavioral observations seem to imply a shooting oviposition technique, the morphological evidence favors stabbing oviposition.

Key Words: Female postabdomen, oviscapt, female reproductive tract, spermathecae, eggs

In 1961 Rettenmeyer described the oviposition behavior of *Stylogaster* (Diptera: Conopidae) above swarms of raiding army ants (Hymenoptera: Formicidae, Ecitoninae) in Panama. "While hovering 30 to 70 cm above the ground, females of *Stylogaster* characteristically flipped their abdomens down, or their whole body shifted downward a few centimeters. This movement suggested that the flies were dropping or *shooting* eggs at the ants below" (p. 1004, emphasis mine). He further reported that on several occasions *Stylogaster* was seen to "dart after cockroaches."

Several other authors have also observed hovering *Stylogaster* above swarms of army ants in Central America (Fig. 1) or Africa: "occasionally one of the flies darting with great quickness toward the ground" (Bates 1863: 366); "now and again darting at them, without doubt for the purpose of ovipositing in their bodies" (Townsend 1897: 23); "suddenly pouncing down (apparently for the purpose of ovipositing)" upon fleeing cockroaches (Carpenter 1915, cited in Stuckenberg 1963); or "pouncing like little warplanes amidst the ants" (Lindner 1955: 23, translated from German). Smith & Cunningham-van Someren (1985) observed that small cockroaches escaping from raiding army ants were attacked by *Stylogaster*. The closest observation was published by Lopes (1937: 260), who observed that some *Stylogaster* females approached an orthopteran and "with an extremely rapid movement inserted an egg in the abdomen between the tergites" (translated from Portuguese). Of the many documented observations none describes contact, grasping, or seizing of the victim.

The actual process of oviposition, i.e., how the egg is inserted into the host's body, remains obscure. Based on the investigation of collected material, Smith (1967: 52) speculated that "the eggs are probably laid by a stabbing movement of the abdomen, with the oviscapt thrust forward between the legs." He further surmised that "the hovering females frequently flick the tips of their abdomens rapidly, but it is doubtful if

Fig. 1. Hovering *Stylogaster* female, Los Alturas, Costa Rica.

oviposition accompanies this movement, since considerable force at close quarters must surely be needed for the egg to penetrate the host cuticle."

The present study follows up on this problem. Could it be, that (A) *Stylogaster* literally shoots eggs at its host, as suggested by the flipping movements of the abdomen (Rettenmeyer 1961) and the fact that no physical contact with the host has been reported? Or (B) are the eggs stabbed into the host's integument, as suggested by Smith (1967, 1979)? Or (C) are the eggs inserted more conventionally after the victim has been seized, which has so far escaped observation? The available information on the female postabdomen of *Stylogaster,* its dart-like eggs, and their random placement on the host's body is reviewed and supplemented by a description of the internal female reproductive tract of *S. stylosa* Townsend. The possibilities for shooting or stabbing oviposition in *Stylogaster* are weighed and approaches for further testing are suggested.

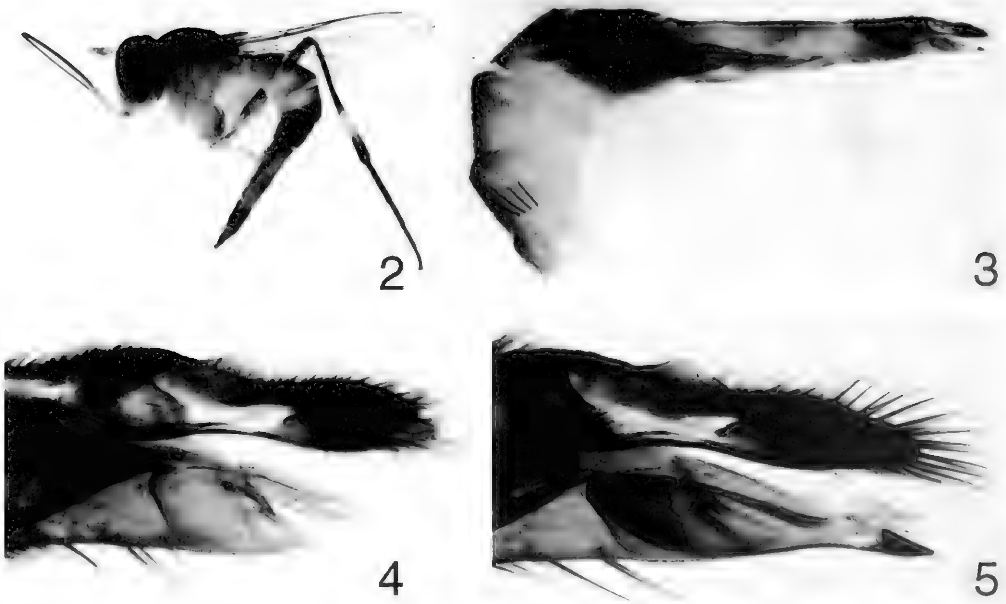
MATERIALS AND METHODS

The description of the internal female reproductive system of *Stylogaster* is chiefly based upon two specimens of *S. stylosa,* which were collected in Costa Rica and dissected immediately after killing. The female reproductive tract was removed, placed on a glass slide, and embedded in Polyvinyllactophenol with an admixture of Chlorazol E (Streng 1976). This medium slowly macerates the tissue while the dye is enriched in unsclerotized cuticle, staining it blue. The terminalia of *S. frauci* Smith were dissected while held in lactic acid. The preparations were investigated and documented with an Olympus BX50 compound microscope equipped with a drawing tube and Olympus SC35 camera, and with a Wild M 400 Photomakroskop.

RESULTS

Female Postabdomen

The female postabdomen of *Stylogaster* has been depicted for various species (Lopes 1937, 1938, 1971, Lopes and Monteiro 1959, Smith 1967, Smith and Peterson 1987). It is characterized by a tubular oviscapt (Smith 1966), which can be extremely long and narrow in some species (Figs. 2, 3). In the Brazilian *S. macrura* Lopes the oviscapt is twice as long as the remainder of the body excluding the antennae (Lopes 1938). The terminalia of *Stylogaster* lack any structures able to penetrate the host integument, as found in other Conopidae (Howell 1967, Smith & Peterson 1987) and other parasitic flies such as Pipunculidae (Hardy 1987) and Pyrgotidae (Steyskal 1987). Instead, the vulva is surrounded by various elongate structures ("egg guides" Smith 1979). The cerci are long and slender, the subanal plate is elongate. Sternum 8 ends in a pair of pointed lobes and bears a pair of long and slender lateral append-



Figs. 2–5. *Stylogaster frauci* female. 2, Total specimen in alcohol. 3, Abdomen cleared in lactic acid; eggs and spermathecae visible within the abdomen; one egg protruding from the vulva. 4, Terminalia. 5, Terminalia of with egg lodged in terminal chamber.

ages with inward curved endlobes (Figs. 4–9).

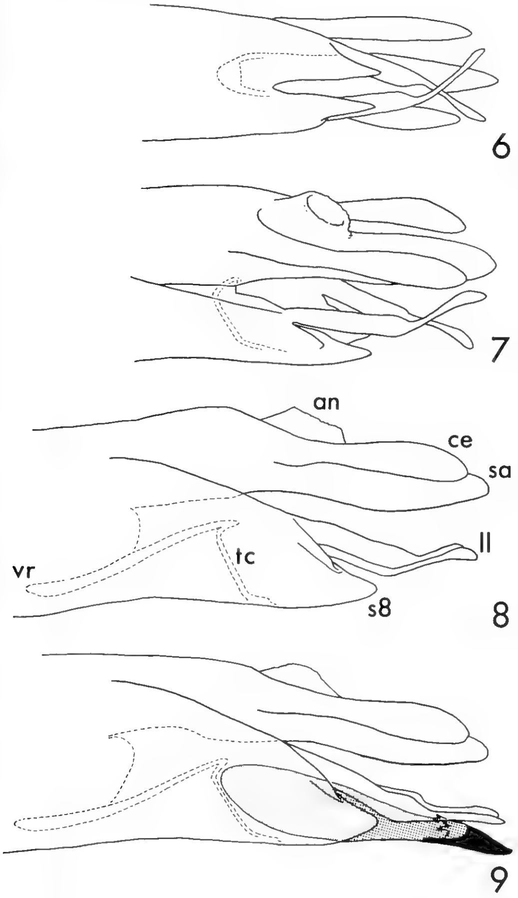
As reported above, *Stylogaster* females frequently "flip" the abdomen while in flight, rapidly flexing it under the body so that the oviscapt is directed anteroventrally. This movement is facilitated by the absence of sclerotized sternites in the first five abdominal segments (Stuckenberg 1963). The resulting flexed posture is often seen in pinned or preserved specimens (Fig. 2).

Egg

The eggs of *Stylogaster* show "remarkable adaptations for the penetration of, and retention in, the host cuticle" (Smith 1966: 264). They have been depicted for various species (Lopes 1937, 1938, 1971 Lopes and Monteiro 1959, Stuckenberg 1963, Smith 1967, 1979, Hinton 1981, Smith and Cunningham-van Someren 1985). In general *Stylogaster* eggs are elongate with a translucent brown chorion. The posterior end is black due to heavy sclerotization, sharply pointed, and bears up to four recurrent spines (Figs. 5, 12). Moreover, a membranous bladder can be extruded from an area near the posterior end. This bladder is believed to be everted by osmosis after the egg is inserted into the host, serving to anchor the egg and erect the recurrent spines (Rettenmeyer 1961, Stuckenberg 1963). *Stylogaster* eggs are very different from those of other conopids, which have a thin whitish chorion, bear appendages at the anterior egg pole in the vicinity of the micropyle, and lack an extrusible bladder (de Meijere 1904, Smith and Peterson 1987).

Egg Placement on the Host Body

The accuracy of *Stylogaster* oviposition resembles that of a faulty shotgun. Stuckenberg (1963) and Smith (1967, 1969) found *Stylogaster* eggs to be positioned randomly on head, thorax, and abdomen of various muscids in South Africa, a few even in the wings. Stuckenberg (1963: 258) explained Rettenmeyer's (1961) findings of a nonrandom distribution of *Stylogaster* eggs on tachinids of the genus *Calodexia*



Figs. 6–9. Terminalia of *Stylogaster frauci*. 6, Ventral view. 7, View from upper left. 8, Lateral view (compare Fig. 4). 9, Lateral view with an egg lodged in the terminal chamber (compare Fig. 5). Abbreviations: an = anus; ce = cerci; ll = lateral lobes on sternum eight; sa = subanal plate; s8 = sternum eight; tc = terminal chamber; vr = scleortized ventral rod.

Wulp from Panama as a result of "*Stylogaster* flies darting after cockroaches which were also being pursued by a number of *Calodexia*. If the tachinids were actively chasing the orthopterons, they would be more prone to receive a *Stylogaster* attack from behind owing to their forward motion which would necessitate some following by the *Stylogaster,* and also because the abdomen would be more susceptible owing to the attitude of the fly and more exposed as the wings would be in use."

The accuracy of host choice seems likewise poor. *Stylogaster* eggs were found not only on members of the presumed hosts, entailing certain Orthoptera, Tachinidae, and silvicolous dung-breeding Muscidae (Lindner 1955, Rettenmeyer 1961, Stuckenberg 1963, Smith 1966, 1969, Smith and Cunningham-van Someren 1985), but on various other insects that might have been hit accidentally (Rettenmeyer 1961, Stuckenberg 1963, Smith 1966, Smith and Cunningham-Van Someren 1985). I even found a *Stylogaster* egg protruding from the median occipital sclerite of a *Stylogaster stylosa* female from Costa Rica.

Internal Female Reproductive Tract

The available information on the internal female reproductive tract of *Stylogaster* has been very limited. Lopes (1937) illustrated the spermathecal ducts of *S. stylata* (Fabricius) with a detail on the spermathecal duct pump. Moreover, Smith (1967) sketched the spermathecae of several African species. The present study of *S. stylosa* complements these data.

The internal female reproductive tract of *Stylogaster stylosa* (Fig. 10) comprises paired ovaries and lateral oviducts, a common oviduct, a tubular vagina, and a sclerotized terminal chamber. Into the dorsal wall of the vagina open two spermathecae, a third, blind duct between the spermathecae, a pair of accessory glands posterior to the spermathecae, and two additional, smaller evaginations, one anterior to the spermathecae and one posterior to the accessory glands. A roughly conical evagination emanates from the anteroventral portion of the vagina.

The ovaries usually contain a large number of mature and fully sclerotized eggs, but apparently no earlier egg stages. One of the *S. stylosa* specimens contained about 120 mature eggs. This is consistent with Smith's (1966, 1967) and Stuckenberg's (1963) findings of 60–128 mature eggs in African *Stylogaster*. Usually some eggs have already proceeded into the oviducts (Figs. 3, 12).

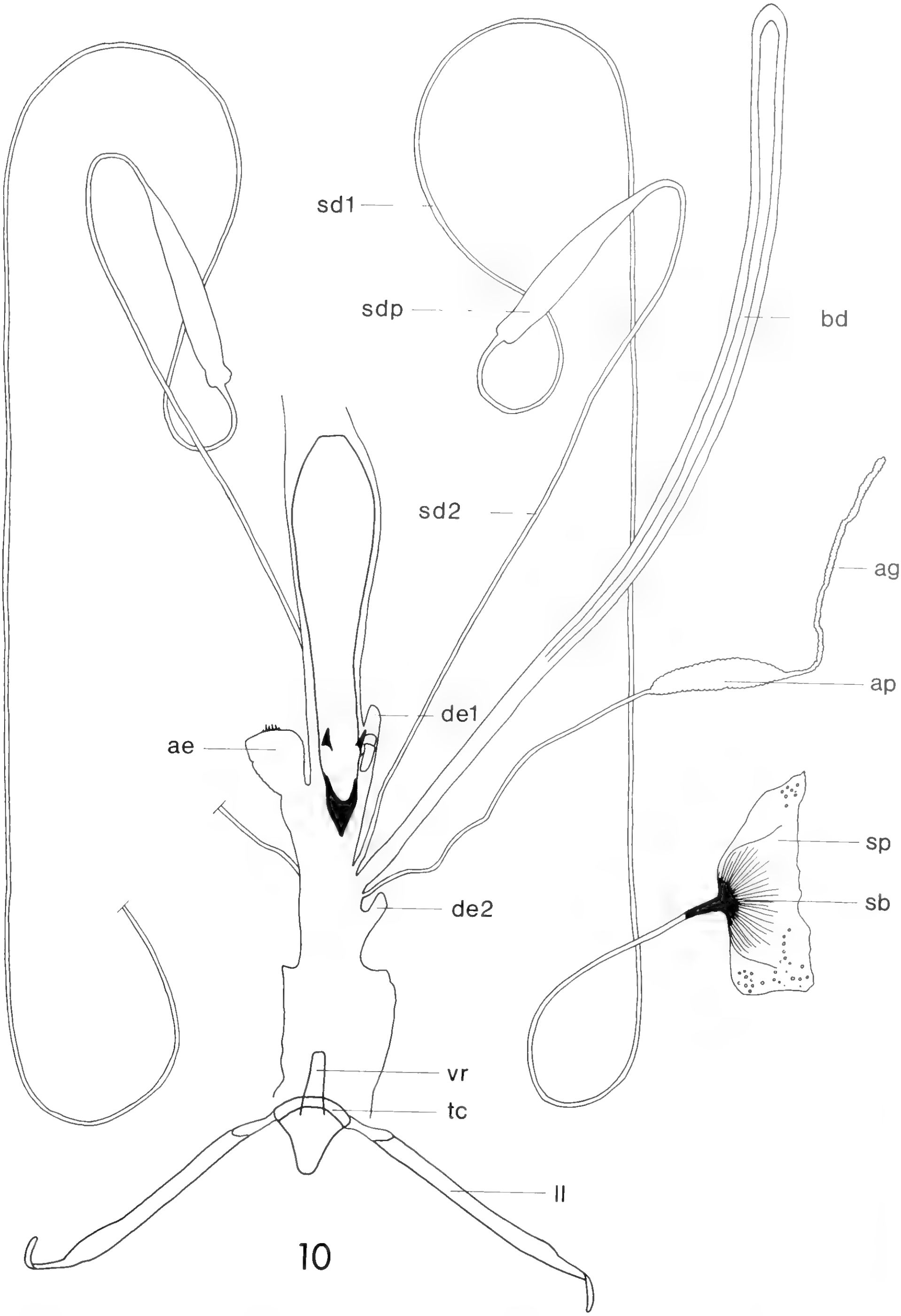


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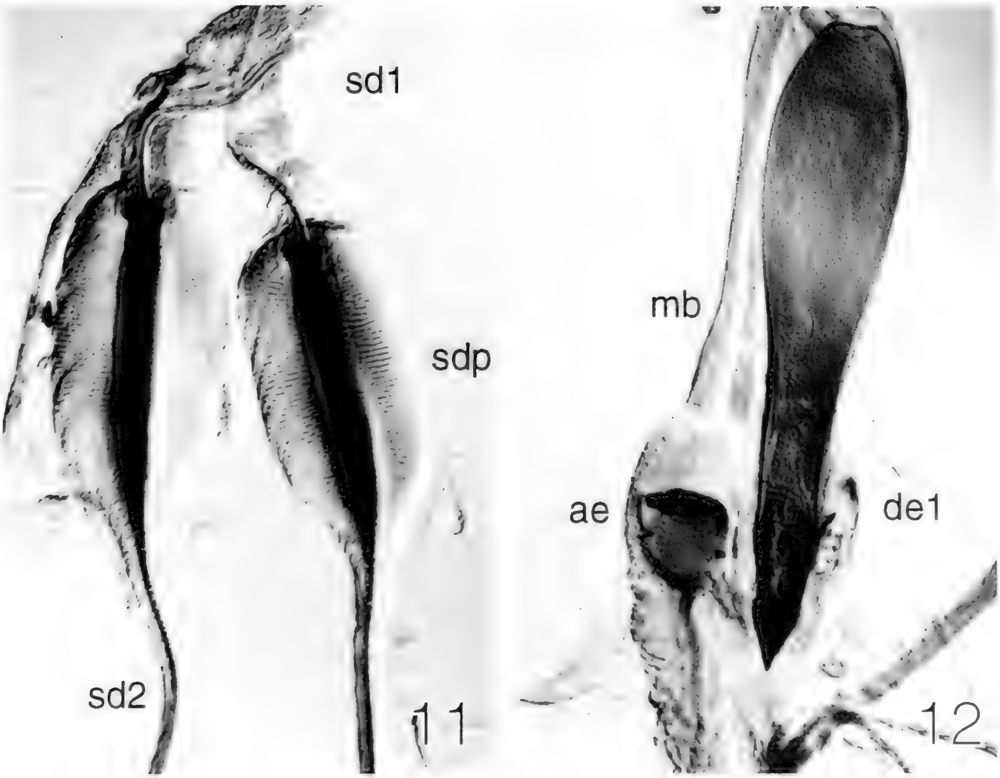
Fig. 10. Internal female reproductive tract of *Stylogaster stylosa.* Ovaries, one spermatheca, and one accessory gland omitted. Abbreviations: ae = anteroventral evagination; ag = accessory glands; ap = accessory gland duct pump; bd = blind duct; de 1, 2 = dorsal evaginations; ll = lateral lobes; tc = roof of the terminal chamber; sb = sclerotized base of the spermatheca; sd 1, 2 = apical and basal part of the spermathecal duct; sdp = spermathecal duct pump; sp = spermatheca; va = vagina; vr = scleortized ventral rod.



Figs. 11–12. Internal female reproductive organs of *Stylogaster stylosa*. 11, Pump structure in the spermathecal ducts. 12, Common oviduct containing an egg and apical portion of the vagina. Abbreviations: ae = anteroventral evagination; de 1 = dorsal evagination; mb = muscle band extending anteriorly from the anteroventral evagination; sd 1 = apical part of spermathecal ducts; sd 2 = basal part of spermathecal ducts.

The two spermathecae are large, round, and almost entirely membranous. However, the spermathecal duct insertion at their base is surrounded by a small sclerotized area from which black spoke-like ridges radiate into the membranous part (Fig. 10). The spermathecal ducts are very long and thin, and show considerable differentiation along their length. The basal one-fourth consists of thick, colorless cuticle surrounded by a sheath of longitudinal muscles. The apical three-fourths consists of thinner, translucent brownish cuticle lacking a muscle sheath. Between the two portions there is an elaborate pump structure, consisting of a thick cuticular cylinder surrounded by a bulky layer of spiral muscles (Fig. 11). A third, blind duct is inserted between the two spermathecal ducts. It is only one-fourth of their length, and its walls consist of thick, multilayered rubber-like cuticle. The homology of this duct is unclear. The accessory glands have a tubular gland reservoir and membranous, narrow ducts, with a widened muscular pump region in their apical part.

The anteroventral evagination (Fig. 12) is thick-walled and surrounded by thick muscles like the rest of the vagina. Moreover, from its anterior wall a conspicuous muscle band extends anteriorly along the ventral side of the common oviduct. The homology of this anteroventral evagination is uncertain, although its position is reminiscent of the ventral receptacle of other acalyptrate Schizophora.

The membranous, tubular part of the vagina opens through a valve into a wider posterior portion, whose ventral wall is reinforced by a sclerotized rod. This rod connects posteriorly to the dorsal rim of a sclerotized oval terminal chamber that is invaginated from the posterior edge of sternum 8 (Figs. 4, 8, 9). In one of the specimens I found an egg fitted into this chamber, its pointed tip protruding from the vulva (Figs. 5, 9). I encountered the same condition in some dissections of *S. currani* Aldrich, *S. biannulata* Say, and *S. frauci*. Smith (1967) similarly figured a *S. leonum* Westwood specimen with the black, pointed tip of an egg protruding from the vulva. In *S. frauci* I could establish that the terminal chamber and surrounding sclerites have the same shape and position, whether containing an egg or not (Figs. 4, 5). There is no apparent evidence of elastic structures that might be able to store and rapidly release energy for the launching of an egg.

Dissections of other *Stylogaster* species show that the spermathecae, accessory glands, and additional dorsal evaginations vary considerably within the genus. These organs are not regarded in the following discussion and will be described in detail elsewhere. The constitution of the ovaries, the vagina, and the anteroventral evagination was found to be quite similar across the species, including African and Australian ones.

DISCUSSION

Three hypotheses regarding the ovipositional technique of *Stylogaster* were suggested in the Introduction: (A) shooting the eggs at the host from above with a flipping movement of the abdomen; (B) stabbing them into the host after a darting approach; and (C) the more conventional method of inserting an egg after seizing the victim. The Results section reviewed the available circumstantial evidence on the morphology of the female postabdomen, the eggs, and their placement in the host, and introduced new evidence regarding the morphology of the internal female reproductive tract. From this evidence the following inferences can be derived.

1. *Stylogaster* does not seize its host for oviposition. Otherwise the egg placement would be expected to be more precise, as is the case in other parasitic flies that seize their hosts, such as *Zodion obliquefasciatum* Macquart (Conopidae, Howell 1967). Oviposition on the head and wings would presumably be avoided in favor of locations, such as the abdomen, where the cuticle is thinner and the larva is likely to gain access to the body tissue. Moreover, grasping or seizing of the host has never been observed in *Stylogaster*. Therefore, the evidence does not support hypothesis C.

2. The penetration of the host cuticle must be achieved entirely by the tip of the egg itself. The terminalia of *Stylogaster* females lack any specialized piercing structures. Instead, the eggs show conspicuous adaptations for piercing, such as a strongly sclerotized and sharply pointed tip.

3. For stabbing oviposition, a fertilized egg would need to be pre-arranged and secured in such a manner, that its pointed tip protrudes from the female postabdomen. This is indeed the case. In several *Stylogaster* specimens, an egg was found in the appropriate position, with the anterior egg pole firmly lodged in the correspondingly shaped terminal chamber, and the posterior, pointed tip protruding from the vulva. It is hard to envision how this position can be achieved without the egg entirely slipping out of the vulva. Apparently the inward curved endlobes of the lateral appendages of sternum 8 take part in securing the egg.

4. On its way from the oviduct to the terminal chamber, the egg has to be fertilized. The anteroventral evagination of *Stylogaster* is similarly positioned and perhaps homologous to the ventral receptacle of other acalyptrate Schizophora (Sturtevant 1925, 1926, Kotrba 1993) and the fertilization chamber of the Calyptrates (Leopold et al. 1978). It is conceivable that it likewise receives the anterior egg pole sometime during oviposition, possibly functioning as the fertilization site. The conspicuous muscle band that extends anteriorly from the

anteroventral evagination obviously pulls this organ into an anterior position while the vagina is extended. If the anteroventral evagination receives the egg in this position and the muscle band is relaxed subsequently, the egg will be propelled posteriorly by the elastic shortening of the extended vagina. Such a mechanism could considerably speed up the processes of fertilization and transportation of the egg.

5. If the egg is already positioned in the terminal chamber while the female is hovering with the ovipositor extended posteriorly (Fig. 1), then the frequently observed flicking movement of the postabdomen could be correlated with accelerating and/or launching the egg. The shooting hypothesis (A) matches the suppositions of some eye-witnesses and would account best for the random egg placement. The flicking of the abdomen is, however, unlikely to provide the necessary kinetic energy for the penetration of the host cuticle. So far, there are no clues to the presence of any other mechanism to accelerate the eggs.

6. In the case of stabbing oviposition (hypothesis B) the required energy could be derived from the stabbing impact, which might indeed be high due to the velocity of the approaching flight, described as "darting" or "pouncing" by eye-witnesses. Upon impact, the protruding posterior egg pole is thrust into the host cuticle while the anterior egg pole is prevented from giving way anteriorly by the sclerotized roof of the terminal chamber. After penetrating the host cuticle, the egg is locked by its recurrent barbs and pulled free of the oviscapt as the *Stylogaster* female flies away.

While this manuscript was being reviewed, Elke Buschbeck (personal communication) told me of an observation from Costa Rica that corroborates the latter scenario. She observed *Stylogaster* females hovering about 30 cm above the ground at the front of an army ant raid. One *Stylogaster* female darted down upon a cockroach, which was quickly running from one leaf to another for shelter. After an impact of a fraction of a second the female flew away, and a light-colored object, presumably an egg, was visible sticking in the thorax of the cockroach.

CONCLUSIONS

Lacking detailed observations, the question of whether *Stylogaster* oviposits by shooting (hypothesis A) or stabbing (hypothesis B) can only be addressed through evaluation of circumstantial evidence. The present study favors the stabbing hypothesis suggested by Smith (1967, 1979). Stabbing is technically easier to conceive than shooting, and agrees well with the morphological evidence and some of the behavioral observations. However, even considering the high speed of a stabbing encounter, hypothesis B does not account as well for the poor egg placement on the host.

For a definitive answer, more detailed observations of oviposition in *Stylogaster* will be essential. This requires field work in South America or Africa, where *Stylogaster* can be seen ovipositing at the front of raiding army ant swarms. Alternatively, living *Stylogaster* females could be collected and provided with appropriate hosts, such as cockroach larvae or silvicolous dung-breeding Muscids, in a free-flying arena. In future investigations of the female postabdomen special attention should be given to structures that are apt to store and instantly release energy, such as parts of resilin or a notch and hook release mechanism.

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EMPOASCA (KYBOS) LUDA DAVIDSON AND DELONG: DISTRIBUTION AND HABITS OF AN IMMIGRANT BIRCH-FEEDING LEAFHOPPER IN NORTH AMERICA (HOMOPTERA: CICADELLIDAE)

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Abstract.—The typhlocybine leafhopper *Empoasca* (*Kybos*) *luda* Davidson and DeLong, though first described from the United States, is believed to be a native European species that has been accidentally introduced into North America. New state records are given for Maryland, New York, and Pennsylvania. Overwintering occurs in the egg stage, and first-generation adults appear from late May through June; a second generation is produced in mid- to late summer. Nymphs feed on lower leaf surfaces of European white birch (*Betula pendula* Roth) in landscape plantings, causing chlorosis on the upper surfaces. Taxonomic characters are provided that allow this minor pest to be distinguished from a generally more serious pest of ornamental birches, the often co-occurring potato leafhopper, *E. fabae* (Harris).

Key Words: Insecta, Cicadellidae, leafhoppers, distribution, birches, feeding habits

Empoasca (*Kybos*) *luda* Davidson and DeLong is a West European typhlocybine leafhopper considered to have been accidentally introduced into the Nearctic Region (Hamilton 1972, 1983, Hamilton and Langor 1987). First collected in North America in 1917 (Davidson and DeLong 1938), this birch feeder has remained little known. Here, I review its taxonomic history, give new U.S. records, and provide notes on its seasonality and habits on ornamental birches. Characters are also provided that facilitate the recognition of *E. luda* on birch trees.

Taxonomic History

Though regarded as adventive in the New World, *E. luda* was first described from North America; Davidson and DeLong (1938) based their description on single specimens from Illinois and Ohio. In Europe, Wagner (1955) described the new species *E. betulicola* from Germany, noting that it superficially resembles the Palearctic *E. smaragdula* (Fallén). Hamilton (1983), recognizing that the birch-feeding species described by Wagner is conspecific with that described by Davidson and DeLong, proposed *E. betulicola* as a synonym of *E. luda*. Ross (1963) incorrectly synonymized *E. luda* under *E. smaragdula* (P. W. Oman, pers. comm. 1989), which specializes on alders (*Alnus* spp.) (e.g., Nuorteva 1952, Le Quesne 1960, Claridge et al. 1968, Claridge and Wilson 1976, Dworakowska 1976, Ossiannilsson 1981).

Empoasca luda has been confused with *E. smaragdula* in both Europe and North America. Apparently the only valid Nearctic record of the latter species is that of Hamilton (1983) from Vancouver, B.C. The records of Poos and Wheeler (1943), who referred to *E. smaragdula* as widely distributed in Canada and occurring throughout the United States, are based on misidentifications (see Hamilton 1983). Their listing of alder, birch, crabapple, linden, poplar, and willow as host plants suggests that several *Empoasca* species, including *E. luda,* are contained in their concept of *E. smaragdula.* Based on Hamilton (1983, 1985), Beirne's (1956) record of *E. smaragdula* from Ontario is also misidentified and refers to *E. luda.*

Kybos and other subgenera of *Empoasca* are sometimes given generic status (e.g., Dlabola 1958, Le Quesne 1960). Here, however, I follow Ossiannilsson (1981), Hamilton (1983), and others who consider *Kybos* a subgenus of *Empoasca.*

North American Distribution

In addition to Illinois and Ohio (Davidson and DeLong 1938), *E. luda* is known from Connecticut, Minnesota, Ontario, and Virginia (Metcalf 1968). Subsequent to the Metcalf catalogue, it has been reported from British Columbia, Ontario (Hamilton 1972, 1983), and Newfoundland (Hamilton and Langor 1987). The following new state records are based on my collections from ornamental *Betula pendula* Roth. Voucher specimens have been deposited in the collections of Cornell University, Ithaca, N.Y.; National Museum of Natural History, Washington, D.C. (USNM); and the Pennsylvania Department of Agriculture, Harrisburg.

MARYLAND: *Allegany Co.,* Frostburg State University, Frostburg, 28 July 1989, 9 May 1990, 3 June 1990; Frostburg, 23 May 1993 (nymphs only); Zihlman, 28 July 1989. NEW YORK: *Tompkins Co.,* Ithaca, 29 Aug. 1989. PENNSYLVANIA: *Berks Co.,* Kutztown University, Kutztown, 18 Aug. 1989; *Huntingdon Co.,* Greenwood Furnace, 28 June 1990; *Lehigh Co.,* Trexlertown, 8 Aug. 1989; *Luzerne Co.,* Wilkes-Barre, 14 Aug. 1989; *Northampton Co.,* Cherryville, 8 Aug. 1989.

Empoasca luda has been recorded from northern Virginia (Arlington) by Wheeler (1942). I have collected it on *B. pendula* in southwestern Virginia (Montgomery Co., Virginia Tech campus, Blacksburg, 2 July 1995), which is the southernmost record of this adventive leafhopper in North America.

Seasonal History, Hosts, and Habits

Notes on seasonality are based on collections and observations of small numbers of individuals (often 10 or fewer) made periodically from European white (or silver) birch (*B. pendula*), the white-barked birch most commonly planted as an ornamental in the United States. In the horticultural trade, this species, as well as the European *B. pubescens* Ehrh., has often been called *B. alba* L. (Santamour and McArdle 1989). At Trexlertown, Pa., *E. luda* was found on a cut-leaved, pendulous birch, probably *B. pendula* 'laciniata'.

The collection of second-and third-instar nymphs in early May in western Maryland suggests that *E. luda* overwinters in the egg stage, as does *E. smaragdula* and apparently other members of the subgenus *Kybos* (Nuorteva 1952, Ossiannilsson 1981). Fourth instars were observed in late May, and in early June about equal numbers of late-instar nymphs and adults were present at Frostburg, Md. In Pennsylvania, adults and late instars of a first generation were found in late June. The collection of nymphs in early to mid-August in Pennsylvania and in late August in New York suggests the occurrence of two generations on ornamental birches. At Arlington, Va., adults have been collected as late as 8 Oct. (USNM collection). This leafhopper is also thought to be bivoltine in Europe (Dworakowska 1976).

Nymphs occur mainly on the abaxial surface of birch leaves, their feeding on mesophyll producing chlorosis on the adaxial surface (Fig. 1). In early season, and when relatively small numbers of *E. luda* are present, the injury consists of light stippling. Only in western Maryland in 1989 was chlorosis conspicuous on the foliage of European white birch.

Recognition Features

Wild and cultivated birches, including *B. pendula,* serve as hosts of numerous leaf-

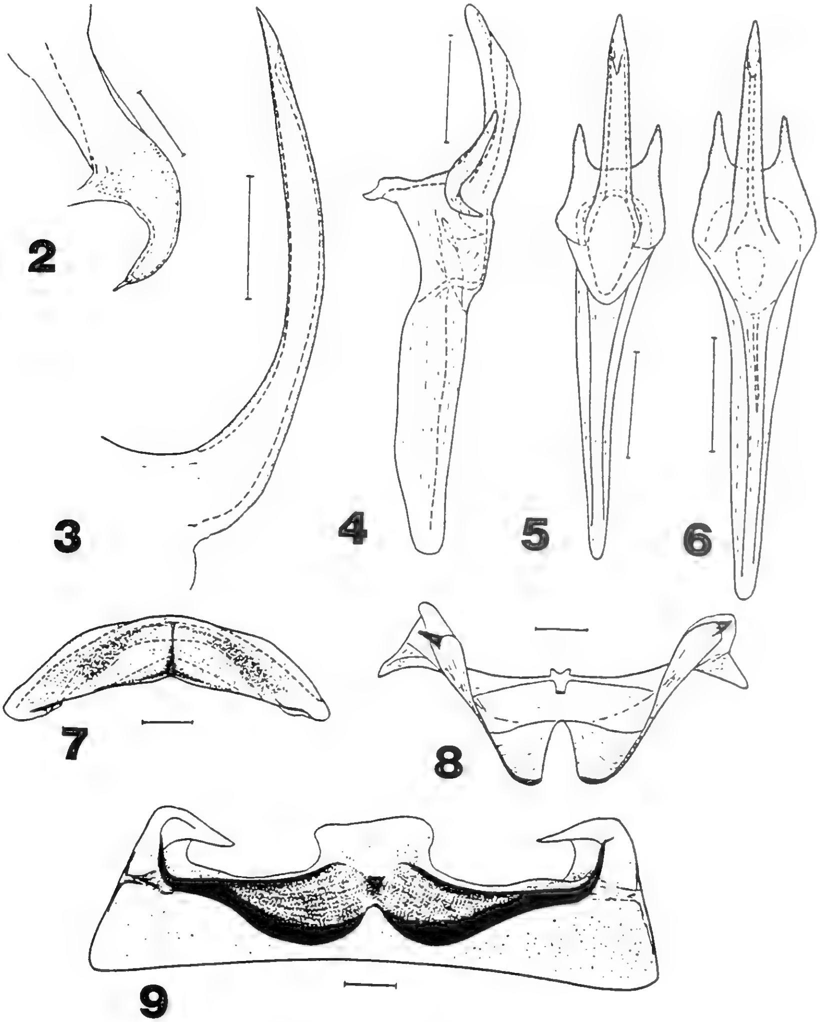
Fig. 1. Chlorosis on foliage of *Betula pendula* caused by the mesophyll-feeding leafhopper *Empoasca* (*Kybos*) *luda*.

hoppers in North America (Varty 1967, Hamilton 1985), but *E. luda* is larger (4.2–4.8 mm) than most other birch-feeding typhlocybines, and it is the only cicadellid species likely to occur on European white birch that has greenish and brown- or black-tinged forewings. Hamilton (1985) noted that adults are green or orange with black stripes, but all specimens I have seen are green or yellowish green with dark markings. *Empoasca fabae (Harris),* the potato leafhopper, frequently co-occurs with *E. luda,* but it is more delicate and smaller (about 3.0–3.5 mm), generally pale green without dark markings, and has a bluntly angled (rather than broadly rounded) vertex. Although *E. luda* has a distinctive habitus among leafhoppers associated with ornamental white birch, it cannot be separated reliably from other typhocybines, especially other members of the diverse genus *Empoasca,* without examining the male genitalia (Figs. 2–9). Male genitalic characters allowing *E. luda* (as *E. betulicola*) to be distinguished from the presumed closely related *E. smaragdula* are discussed and illustrated in LeQuesne (1961), Dworakowska (1976), and Ossiannilsson (1981).

DISCUSSION

Empoasca luda is one of the relatively few Old World insects now established in the New World that was first described from North America; the mullein thrips, *Haplothrips verbasci* (Osborn), is believed to represent a similar example (Stannard 1968). The birch specialist *E. luda* is one of numerous Palearctic leafhoppers suggested to have been accidentally introduced into North America with shipments of nursery stock (Hamilton 1983, Hamilton and Langor 1987). The adventive status of *E. luda* in the Nearctic region is supported by my failure to collect this species in northeastern North America on native birches such as *B. lenta* L., *B. papyrifera* Marsh., or *B. populifolia* Marsh. Within the Holarctic subgenus *Kybos,* an association with *Alnus* and *Betula* (Betulaceae) is considered secondary, the ancestral hosts belonging to either *Populus* or *Salix* (Salicaceae) (Ross 1963).

Empoasca luda has not been reported previously as a pest of ornamental birches. As a mesophyll feeder, it causes chlorosis on the foliage of European white birch. Chlorosis is typically restricted to relatively few branches, although in 1989 injury was widespread on three trees in a Maryland landscape planting. Horticulturists, plant inspectors, and pest-management specialists, therefore, should be aware of this leafhopper's potential for causing aesthetic injury to European white birch. They should not, however, mistake *E. luda* for *E. fabae,* a mesophyll and occasional phloem feeder (e.g., Backus 1989) that can cause more serious problems on ornamental birches—stunting, distortion, and swelling of twigs—in nurseries and landscape plantings (Tashiro 1973, Valley and Blosser 1986, Johnson



Figs. 2–9. *Empoasca* (*Kybos*) *luda*, male terminalia. 2, Left anal collar appendage from left. 3, Left pygofer appendage from outside. 4, Aedeagus from left. 5, Aedeagus in ventral aspect. 6, Aedeagus in ventral aspect. 7, 2nd abdominal sternum from below. 8, 2nd abdominal tergum from above. 9, 3rd abdominal tergum from below. Scale = 0.1 mm (From Ossiannilsson 1981:436).

and Lyon 1988). I agree with Raupp (1990), who emphasized that managing arthropod pests of woody ornamentals depends on accurate identification of both the host plants and their arthropod associates, pests as well as beneficial and neutral species. *Empoasca luda* should be considered an occasional minor pest of European white birch.

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THE GENUS *PLESKEOLA* STACKELBERG (DIPTERA: SYRPHIDAE), A JUNIOR SYNONYM OF *PARHELOPHILUS* GIRSCHNER

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Abstract.—The genus *Pleskeola* (**n. syn.**) is synonymized with *Parhelophilus*. The species (*porcus* and *sibiricus*, **n. comb.**) associated with the name *Pleskeola* are redescribed. A checklist and key to species of *Parhelophilus* is presented. Four **new synonyms** and one **new combination** are reported (*Helophilus anniae* Brimley 1923 = *flavifacies* Bigot 1883; *Parhelophilus obscurior* Violovitsh 1960 and *Helophilus citricornis* Shiraki 1968 = *kurentzovi* Violovitsh 1960; *Parhelophilus currani* Fluke 1953 = *laetus* Loew 1863; *Helophilus pilosus* Hunter 1897 is transferred to *Lejops (Lejops)*).

Key Words: key, holarctic, bogs

This is a tale of two rare flower flies, which are known from only a few specimens collected in the boreal forest. One flower fly was the basis of a genus-group name and is currently known only from three specimens collected in Finland and Siberia. The other flower fly is known from more specimens, about 100 in all, and appears to be restricted to bogs in North America. As part of a revision of the higher classification of flower flies, I have sought to re-examine the types of all genus-group names and to place those types into my classification. This eventually brought me to *Pleskeola sibirica* Stackelberg, a genus and species-group name proposed as new by Stackelberg for a unique male collected in central Siberia. On seeing the second known specimen of *Pleskeola,* I immediately recognized it as being close, if not the same as a rare bog fly (*Parhelophilus porcus* (Walker)) that I had once collected in northern New Hampshire. While both *porcus* and *sibiricus* are unusual and share distinctive characters, the two species otherwise agree with the characteristics of *Parhelophilus.* Why *Pleskeola* is here reduced to a junior synonym of *Parhelophilus* is outlined below. What remains of interest is why the species upon which the genus-group name is based is so rare in collections. Is *sibirica* a bog species, like its sister (*porcus*), and merely rare because northern bogs are poorly collected in Russia? Perhaps this treatment of these two species will encourage field people to more closely examine bogs and look for these unusual flies.

The terminology and characters used generally follow those used in the Manual of Nearctic Diptera and all my standards are defined and illustrated in a comprehensive glossary (Thompson 1997). The format of the checklist follows the standards of the Biosystematic Database of World Diptera (see Thompson 1997).

Genus *Parhelophilus* Girschner

Helophilus subg. *Parhelophilus* Girschner 1897: 604. Type species, *Syrphus frutetorum* Fabricius by subsequent designa-

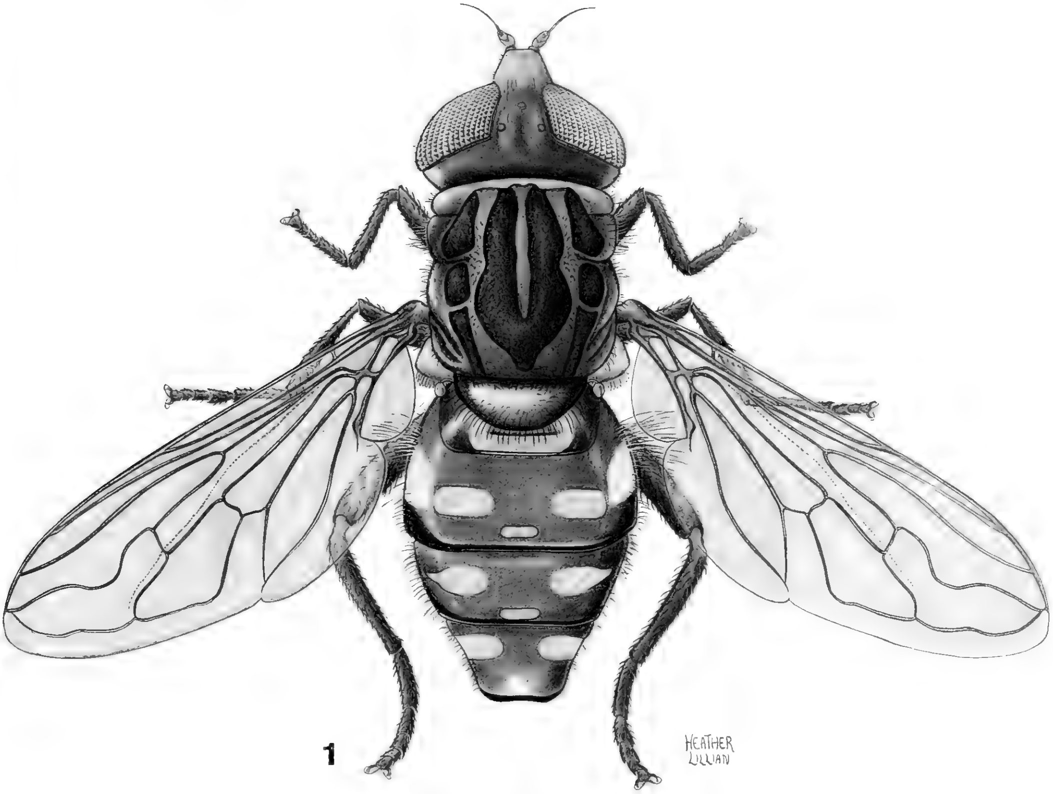


Fig. 1. *Parhelophilus sibiricus*, male, habitus, dorsal view.

tion of Curran and Fluke 1926: 230). Curran and Fluke 1926: 230 (revision, Nearctic spp.); Goffe 1944: 129 (nomenclature), 1945: 276 (type species); Hull 1949: 387 (description).

Pleskeola Stackelberg 1924: 25. Type species, *Pleskeola sibirica* Stackelberg by original designation. Sack 1931: 276 (description); Hull 1949: 402 (diagnosis); Stackelberg 1970: 80, 1988: 121 (reference in key); Goot 1981: 211 (reference in key); Violovitsh 1983: 114, 129 (reference in key). **New synonym.**

Head: Face pale, yellow to white, narrow, slightly longer than broad, occupying about ⅓ of head width, straight to concave beneath antennae, without distinct medial tubercle, pollinose and pilose laterally, pollinose and bare medially; frontal prominence low, at dorsal ⅓ of head; vertex black, pollinose, pilose, rectangular, slightly longer than wide; ocellar triangle variable, from broader than long to longer than broad; eye bare or pilose; always dichoptic in males; antenna short, less than ½ as long as face; basoflagellomere oval; arista bare, slightly longer than antenna.

Thorax: Broader than long, long pilose, usually with longitudinal pale pollinose vittae on mesonotum (absent or greatly reduced in *obsoletus*); meso-katepisternum continuously pilose from ventral to dorsal margins; metathoracic spiracle small, slightly smaller than basoflagellomere; meso-anepimeron bare posteriorly; katepimeron bare; meron bare; metasternum usually pilose (bare in *divisus*); plumula elongate, unbranched; subscutellar fringe absent. Legs: Hind femur slightly swollen; hind tibia slightly arcuate, with basoventral carina on basal ½ or less, without apical calcar. Wing: Microtrichose; cell R1 open;

cell R4+5 with short petiole, with petiole about as long as crossvein h; stigmatic crossvein present.

Abdomen: Suboval, with paired lateral light colored pollinose maculae on dorsum.

Girschner (1897), on the basis of a study of the calypter of higher Diptera, divided the genus *Helophilus* into subgenera. He defined most of these subgenera with characters, but *Parhelophilus* was defined by exclusion (that is, those species which did not fit the other defined subgenera). At first, most workers ignored Girschner's action as they could not understand the characters on which the group was based and, hence, treated *Parhelophilus* as a synonym of *Helophilus.* As Verrall (1901: 524–525) noted, *Parhelophilus,* as construed by Girschner, was a heterogeneous group (two species belonged to *Parhelophilus* of current authors, one to *Lejops* Rondani). Curran and Fluke (1926) designated a type species, recognized *Parhelophilus* as a distinct group, and treated the group as a genus. North American workers have followed Curran and Fluke as have some Palaearctic workers. The characters that separate *Parhelophilus* from *Helophilus* are: 1) presence of stigmatic crossvein; 2) entirely pollinose face, without a shiny medial vitta; and 3) short, suboval and compact abdomen. *Parhelophilus* differs from *Lejops* in the 4) lack of an apical calcar on the hind tibia as well as the suboval abdomen. *Pleskeola* shares all these characteristics with *Parhelophilus.*

Stackelberg (1924) erected his genus *Pleskeola* on the basis of the pilose eyes, an unusual character state among species related to *Helophilus* (he also noted the slightly sinuate vein R4+5 and in contrast to *Mallota,* the dichoptic males). Stackelberg's original description was brief and in Latin. Because the species on which the genus was based was rare, most subsequent workers merely repeated the original description and/or left *Pleskeola* as unplaced or a genus of dubious status.

Eye pilosity is a character of variable importance among flower flies. In most genera, the eyes of all included species are either bare or pilose. Within some genera, however, the character is variable, with some species being bare eyed and others pilose (e.g., *Syrphus*). In some species, the male eyes are pilose and the females' are bare (e.g., *Cheilosia latifrons* (Zetterstedt)). The eye pilosity of *sibirica* is irrelevant as a genus-group character as other characters reveal a sister-group relationship to one species of *Parhelophilus* and common relationships with all species of *Parhelophilus. Parhelophilus porcus* and *sibiricus* have the 1st and 2nd sterna (figs. 11–12) fused and a distinct dark pollinose body pattern (figs. 1–2), both characters found no where else among the helophiline flower flies. These two species share a characteristic basoventral process on the hind femur (figs. 14–15) in males with *fruterorum* and *divisus.* As noted above, *sibirica* shares all the characters of the genus *Parhelophilus.* Hence, *Pleskeola* is here considered a synonym of *Parhelophilus* (new synonym).

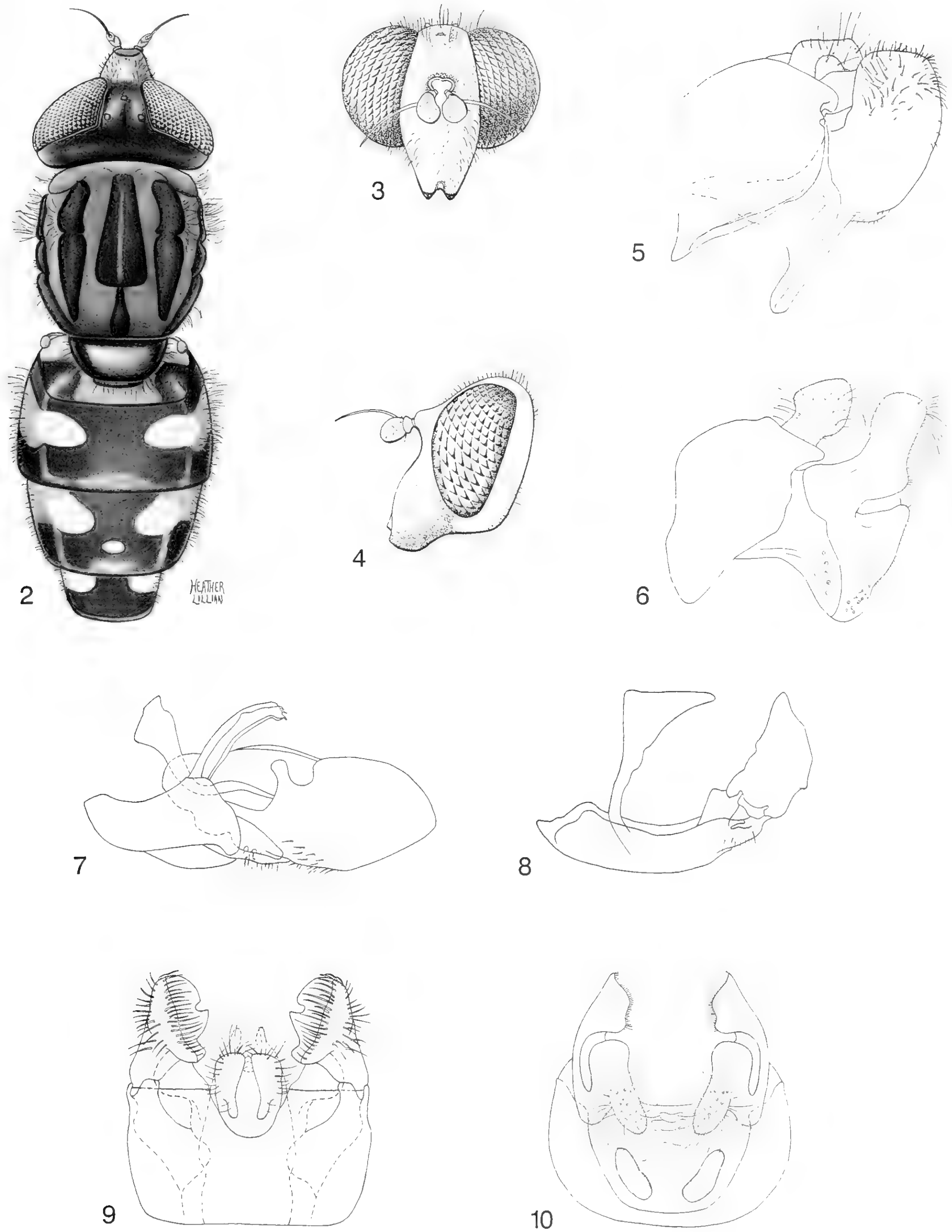
Parhelophilus porcus (Walker)
(Figs. 2, 6, 7, 10, 11, 13, 15)

Eumerus porcus Walker 1849: 554 ♀ [error for ♂] Ontario, Hudson's Bay, Albany River, St. Martin's Falls (LT ♂ BMNH here designated). Osten Sacken 1858: 48 (catalog citation), 1875: 61 (catalog citation, ?=*Eristalis*).

Helophilus porcus: Osten Sacken 1878: 134, 250 (catalog citation, note on types); Williston 1887: 197 (description); Aldrich 1905: 394 (catalog citation); Osburn 1907: 3 (British Columbia), 1908: 10 (British Columbia); Graenicher 1910: 41 (Wisconsin); Fluke 1922: 245 (Wisconsin); Johnson 1923: 10 (Maine), 1925: 174 (New England); Wirth et al. 1965: 619 (catalog citation).

Tubifera porcus: Kertész 1910: 259 (catalog citation).

Parhelophilus porcus: Curran and Fluke 1926: 232 (description, distribution, figures (head, abdomen)); Petch and Malthais 1932: 51 (Quebec); Strickland



Figs. 2–10. Features. 2, *Parhelophilus porcus*, habitus, dorsal view. 3, *P. sibiricus*, male, head, frontal view. 4, *P. sibirica*, male, head, lateral view. 5, *P. sibiricus*, male genitalia, 9th tergum and associated parts, lateral view. 6, *P. porcus*, male genitalia, 9th tergum and associated parts, lateral view. 7, *P. porcus*, male genitalia, 9th sternum and associated parts, lateral view. 8, *P. sibiricus*, male genitalia, 9th sternum and associated parts, lateral view. 9, *P. sibiricus*, male genitalia, 9th tergum and associated parts, dorsal view. 10, *P. porcus*, male genitalia, 9th tergum and associated parts, dorsal view.

1938: 203 (Alberta); Cole & Schlinger 1969: 326 (descriptive note, distribution western North America); Miliczky and Osgood 1979: 21 (Maine, flower (*Vaccinum* spp.)).

Head: Face yellowish white, white pollinose and pilose; gena black, shiny and bare anteriorly, white pilose and grayish-white pollinose posteriorly; front black, gray pollinose, black pilose; frontal lunule yellow; vertex black, black pollinose and pilose except for some yellow pile on ocellar triangle; occiput black, grayish-white pollinose, black pilose dorsally except some yellow pile posterior to ocellar triangle, white pilose ventrally. Eye bare. Antenna orange, black pilose.

Thorax: Black, mainly yellow pilose, sparsely gray pollinose, with black pollinose vittate pattern on mesonotum (see Fig. 2); postpronotum yellow pilose; mesonotum with intermixed black pile; anepisternum black pilose dorsoposteriorly; halter yellow; calypter and plumula white; scutellum black, dull black pollinose except broadly shiny marginally, black pilose except yellow pilose marginally. Wing microtrichose. Legs mainly black and black pilose; femoral-tibial joints of fore and mid legs broadly orange; fore and mid tarsi yellow, pale pilose; white pilose on coxae, posteriorly on mid femur, anterobasally on hind femur. Hind femur of male with basoventral process (Fig. 15).

Abdomen: Black, mainly black pilose; tergum 1 bluish-gray pollinose except black pollinose macula apicolaterally, short black pilose except white pilose laterally; tergum 2 with mediolateral small orange macula, shiny apically, elsewhere black pollinose except for medial white pollinose macula, yellow pilose on pale areas and basolaterally; terga 3 & 4 black pollinose except shiny apically and with medial grayish white pollinose macula, yellow pilose basolaterally; tergum 5 gray pollinose, white pilose; genitalia white pilose, sparsely pollinose; sterna black, subshiny, very sparsely pollinose, shiny medially, white pilose; 2nd & 3rd sterna of male with apicomedial patches of long curved bristles (Fig. 11). Male genitalia (Figs. 6, 7 & 10): surstyle with broad posteromedial cleft and without a dorsomedial notch on dorsal lobe; superior lobe short, only ⅔ as long as hypandrium.

Type.—*Eumerus porcus* Walker, lectotype ♂ BMNH, London, labeled "Hudson's Bay [reverse] 47 14," "Hudson's Bay, pres. by, G. Barnston, 44. 17," and with the appropriate Austen labels. I accept this male as a syntype as Walker usually sexed flower flies by the condition of the eyes. Hence, the dichoptic male of *porcus* would appear to Walker as a female. Osten Sacken (1878) reported two "well-preserved specimens" in the British Museum, unfortunately only one was found and it is now headless.

Flight period.—May–July.

Distribution.—British Columbia to New Brunswick, south to Wisconsin and Maryland. The southernmost record (Maryland) is from the 1965 Diptera catalog (Wirth et al., 1965: 619). I have not found its source. The Pennsylvania records from "North Mountain" are from Ricketts near Lake Ganoga (Johnson 1914).

Biology.—Nothing is known of the immature stages of *porcus,* but by phylogenetic inference these will be aquatic as all eristaliine flower fly larval are of the rat-tailed maggot type. The adults are collected in association with bogs, where they have been frequently collected on flowers (*Fragaria, Houstonia, Ledum groenlandicum, Potentilla,* and *Rubus*). Most of the known sites for *porcus* are the typical kettlehole bogs (Bingham Pond, Wilson Mills), but some (Laurel Lake site) are better described as fens bordered by spruce, fir and hemlock (see Johnson 1985 for details on the bogs of northeastern USA). Unfortunately, for most collected specimens, no site information is available.

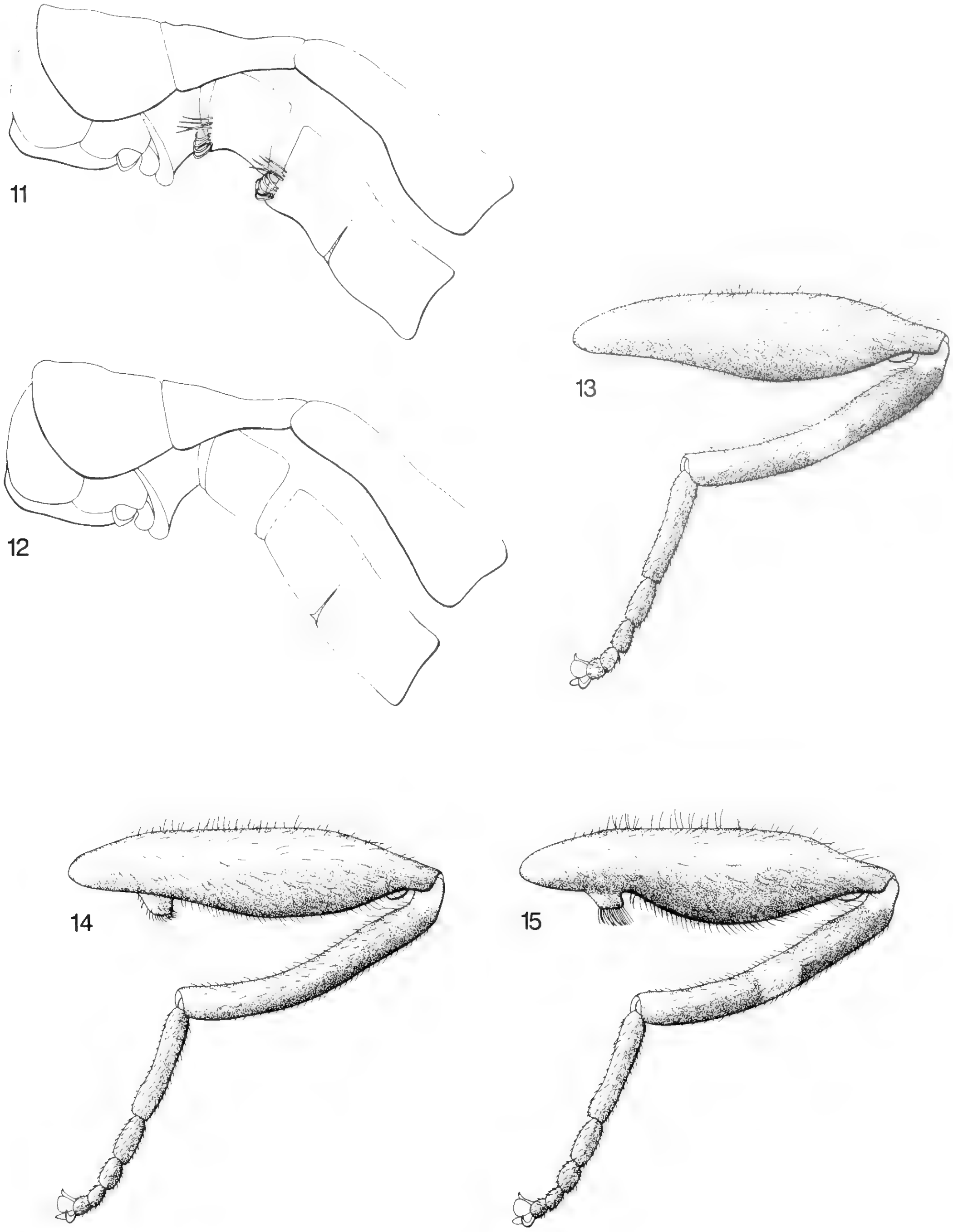
Material Examined.—ALBERTA: Banff, 4 July 1922, C. B. D. Garrett (1 ♀ Curran & Fluke 1926: 232). MANITOBA: Cedar

Lake, July 1993, Brues (1 ♂ USNM); Gimli, 13 June 1923, A. J. Hunter (1 ♂ - Curran & Fluke 1926: 232). ONTARIO: Ottawa (1 ♂ USNM); Lake Abitibi, Low Bush, 3 July 1925, N. K. Bigelow (1 ♂ MCZ); McDiarmid (Curran & Fluke 1926: 232). QUEBEC: Montreal, June 15 1906 (1 ♀ Curran & Fluke 1926: 232). CONNECTICUT. Litchfield Co., Salibury, 5 km NW of town center, bog at edge of Bingham Pond, 1,894 ft, 14–16 June 1983 (5 ♂ CTM), 20 June 1984 (1 ♂ CTM), 23 May 1985 (2 ♂ 1 ♀ CTM), 4 June 1986 (1 ♂ 1 ♀ CTM), all specimens collected in Malaise trap among ericaceous shrubs at the edge of a pond surrounded by bog mat with spruces. MAINE. Oxford Co., Lincoln Plantation, Maine highway 16, 6 miles south of Wilsons Mills, "Wilson Mills Bog," [a sphagnum bog dominated by black spuce and larch]: 4 June 1976 (1 ♂ FEE), F. D. Fee; 19 June 1982 on *Ledum groenlandicum* (2 ♂ FEE) F. Fee, F. D. Fee (2 ♂ FEE); 24 June 1982 on *Ledum groenlandicum* (1 ♂ 1 ♀ FEE), F. D. Fee, F. Fee (1 ♂ FEE); 6 June 1986 on *Ledum groenlandicum,* F. D. Fee (1 ♂ FEE); 29 May 1987 on or about *Fragaria,* F. D. Fee (1 ♂ 1 ♀ FEE); 3 June 1989 on *Fragaria,* F. D. Fee (1 ♂ FEE); 19 June 1982, C. T. Maier (1 ♂ CTM). Penobscot Co., Passadumkeag, 26 May 1977, E. Miliczky (1♂ USNM). NEW YORK: Essex Co., Lake Champlain, Corlaer Bay, June 1939 (1 ♂ 1 ♀ USNM). NEW HAMPSHIRE. Coos Co.: Errol, 8 km SW junction of New Hampshire highways 16 and 26, 19 June 1982, C. T. Maier (1 teneral ♀ CTM); Pittsburg, Rt. 3, Connecticut Lakes, 22–24 June 1972 B. J. & F. C. Thompson (1 ♂ USNM); Pittsburg, Back Lake, 17 June 1982 on *Fragaria* (2 ♀ FEE), 22 June 1982 (1 ♂ 1 ♀ FEE), 18 June 1983 (1 ♂ 1 ♀ FEE), 3 June 1986 on *Fragaria* (2 ♂ 1 ♀ FEE), all collected by F. D. Fee; Clarksville, Hurlbert Swamp, 15 June 1984 F. D. Fee (1 ♂ FEE); 2nd Connecticut Lake, Route 3 west of Dam, 3–5 June 1988 on *Fragaria* (1 ♂ FEE) and on *Ledum groenlandicum* (1 ♂ 1 ♀ FEE), all collected by F. D. Fee; Connecticut Lakes, Scott Bog, 8 June 1990 on *Fragaria* (1 ♂ FEE), 14 June 1990 on Taraxacum (1 ♂ FEE), both collected by F. D. Fee. Sullivan Co.: Cornish Flat, 12 July 1971 A. G. Lavallee (1 ♂ 1 ♀ USNM). VERMONT, Windham Co., Laurel Lake, near Jacksonville, 30 May 1977, on *Houstonia,* H. D. Pratt (1 ♂ 1 ♀ USNM). PENNSYLVANIA. Centre Co.: Black Moshannon State Park, 15 May 1977 (1 ♀ FEE), 11 June 1977 (1 ♀ FEE), 16 June 1978 (1 ♂ 2 ♀ FEE), 22 May 1979 on *Taraxacum* (1 ♀ FEE), 13 June 1979 on *Rubus* (3 ♂ 1 ♀ FEE), all collected by F. D. Fee; Bear Meadows Natural Area, 17 June 1987 on *Ranunculus* (1 ♂ FEE), 26 June 1989 (1 ♀ FEE), all collected by F. D. Fee. Tioga Co.: Morris, 6 km Northwest of, State Game Lands #268, 15 June 1979 in boggy sedge meadow with some open water (2 ♂ FEE), 20 June 1979 (2 ♂ FEE), 4 June 1980 on *Rubus* and *Potentilla* (3 ♂ 3 ♀ FEE), 13 June 1980 on *Rubus* (2 ♂ 2 ♀ FEE), 23 June 1980 on *Rubus* (1 ♂ FEE), 1 June 1981 on *Rubus* & *Fragaria* (3 ♀ FEE), 7 June 1981 on *Rubus* & *Potentilla* (4 ♂ 1 ♀ FEE), all collected by F. D. Fee. Luzerne Co., North Mountain [=Ricketts, near Lake Ganoga], June 6 ?? (1 ♂ USNM), June 4 ?? (1 ♀ MCZ), June 8 1898 (2 ♂ 2 ♀ USNM, 1 ♂ 1 ♀ MCZ) all collected by C. W. Johnson.

Parhelophilus sibiricus (Stackelberg),
NEW COMBINATION
(Figs. 1, 3–5, 8, 9, 12, 14)

Pleskeola sibirica Stackelberg 1924: 25. Type-locality: Russia, "Sibiria centralis, Obj-Enisseijskij kanal. septen. et orientem versus Enisseisk." HT ♂ ZISP. Sack 1931: 276 (description); Stackelberg 1970: 80, 1988: 121 (description, figures (abdomen, wing); Goot 1981: 211 (reference in key, figures (abdomen, wing); Violovitsh 1983: 129, 1986: 123 (Siberia); Peck 1988: 193 (cat. cit.)

Head (Figs. 3, 4): Face yellowish white, white pollinose and pilose; gena black,



Figs. 11–15. Features, ventrolateral views. 11–12, Abdomen, male. 11, *Parhelophilus porcus*. 12, *P. sibiricus*. 13–15, Hind leg, lateral view. 13, *P. porcus*, female. 14, *P. sibiricus*, male. 15, *P. porcus*, male.

shiny and bare anteriorly, yellow pilose and gray pollinose posteriorly; front yellowish white, white pollinose and pilose; frontal lunule yellow; vertex black, black pollinose and pilose except for some yellow pile on ocellar triangle; occiput black, gray pollinose, black pilose dorsally except some yellow pile posterior to ocellar triangle, yellow pilose ventrally. Eye brown pilose. Antenna brown, black pilose.

Thorax: Black, mainly black pilose, sparsely gray pollinose, with darker pollinose vittate pattern on mesonotum (see Fig. 1); postpronotum yellow pilose; mesonotum with intermixed yellow pile; katepisternum yellow pilose; halter yellow; calypter and plumula white; scutellum black, dull brown pollinose except shiny marginally, black pilose. Wing microtrichose. Legs black, mainly black pilose; yellow pilose on coxae, posteriorly on mid femur, anterobasally on hind femur. Hind femur of male with basoventral process (Fig. 14).

Abdomen: Black, mainly black pilose; tergum 1 black pollinose, short black pilose except white pilose laterally; tergum 2 with mediolateral small orange macula, shiny apically, else where black pollinose except for medial white pollinose macula, yellow pilose on pale areas and basolaterally; terga 3 and 4 black pollinose except shiny apically and with medial grayish white pollinose macula, yellow pilose basolaterally; genitalia black pilose, dull pollinose; sterna black, subshiny, very sparsely pollinose, white pilose; sterna of male simple (Fig. 12). Male genitalia (Figs. 5, 7, and 9): surstylus without posteromedial cleft, with small medial notch on mesial side of dorsal lobe; superior lobe elongate, longer than hypandrium.

Distribution.—Russia (Karelia & Siberia).

Material examined.—RUSSIA. Karelia: "Paanajarvi [=Ozero Olanga, 66°8′N 30°0′E], 833, R. Frey" (UZMH, 1 ♂). Siberia: "23 May 1908, Tshugunov, Obj Enissejskij Canal, NE of Enisseisk" [= Ob' - Yenisey rivers Canal, northeast of Yeniseysk](ZISP, Holotype ♂).

Stackelberg (1970: 80) listed Finland on the basis of the Frey specimen. Hackman (1980) did not list the species from Finland because the Frey specimen, which was collected in Finland, was collected at a locality which is now in Russia! This specimen was unknown to Sack (1931) and Violovitsh (1983, 1986), who stated that it was known only from the unique original male. Peck (1988) gave Yakutia as additional locality. Unfortunately, I have been unable to find the specimen on which this record is based.

KEY TO THE SPECIES OF *PARHELOPHILUS*

1. Female 15
– Male 2
2. Hind femur without a tubercle (Fig. 13) . . . 7
– Hind femur with a ventral subbasal tubercle covered with black setulae (Figs. 14–15). . . 3
3. Abdomen with yellow maculae on at least 2nd tergum; thorax entirely yellow pilose; abdominal sterna without modified hairs 5
– Abdomen with gray pollinose maculae on all terga (Figs. 1–2); mesoanepisternum and postalar callus black pilose. Hind femur entirely black 4
4. Eye pilose; abdominal sterna without tufts of specialized pile (Fig. 12); front yellow pilose . . . . *sibiricus*
– Eye bare; 2nd and 3rd abdominal sterna with apical submedial tufts of modified pile (Fig. 11); front black pilose . . . . *porcus*
5. Hind femur black on basal ⅔ or more; hind femoral process elongate, with long setae . . . . *fruterorum*
– Hind femur yellow on basal ⅓ or more; hind femoral process short, with short setae 6
6. Vertex broad, about as long as broad, black pilose; hind trochanter with black setulae; front tarsus with apical 2 tarsomeres dark; metasternum bare . . . . *divisus*
– Vertex narrow, almost twice as long as broad, yellow pilose on upper ⅓ or more; hind trochanter yellow pilose, without black setulae; front tarsus entirely orange; metasternum pilose . . . . *flavifacies*
7. 6th and most of 7th abdominal segments shiny; vertex completely yellow pilose . . . 14
– Genitalia segments grayish yellow pollinose; vertex partially black pilose 8
8. 2nd and 3rd terga without yellow maculae (see couplet 11 for other characters) . . . *brooksi*

– 2nd and 3rd terga with large yellow lateral maculae 9

9. Vertex narrow, at least twice as long as wide posteriorly; ocellar triangle narrow; medial ocellar distance much greater than distance between lateral ocelli . . . . *flavifacies*

– Vertex broader, about as long as wide posteriorly; ocellar triangle broader, medial ocellar distance equal to or less than distance between lateral ocelli 10

10. Front tibia extensively dark apically; hind femur black basally 13

– Front and middle tibiae yellow; hind basotarsomere without black setae 11

11. Hind femur black on basal ¾, rarely very narrowly yellow on base, with long pile basoposteriorly . . . . *versicolor*

– Hind femur broadly yellow basally, yellow on at least basal ¼ or more, without any long pile 12

12. Front yellow pilose; cercus elongate posteriorly . . . . *laetus*

– Front black pilose; cercus oval . . . . . *kurentzovi*

13. Mid tibia extensively dark apically; hind tibia black on basal and apical ⅓, yellow medially; hind basotarsomere with a few black bristles apicolaterally, without long lateral pile; front partially or entirely yellow pilose . . . . *rex*

– Mid tibia entirely yellow; hind tibia yellow on basal ⅔, black apically; hind basotarsomere without black bristles, with long pile laterally; front black pilose . . . . *consimilis*

14. Mesonotum without distinct pollinose vittae; hind femur narrow and arcuate; genitalia large, with 6th segment as long as 4th tergum; hind basotarsomere shorter pilose, with pile only about as long as tarsal width . . . . *obsoletus*

– Mesonotum with distinct pollinose vittae; hind femur broader and not arcuate; genitalia smaller, with 6th segment only about ½ as long as 4th tergum; hind basotarsomere longer pilose, with pile distinctly longer than tarsal width . . . . *integer*

15. Hind femur entirely black; abdomen black, with gray pollinose maculae on all terga; mesonotum and mesoanepisternum extensively black pilose; fore and mid femora extensively black pilose; hind basotarsomere with black apicolateral bristles along anterior edge; ocellar triangle broad, with medial ocellar distance much less than distance between lateral ocelli . . . . *porcus*

– Femora much more extensively yellow; abdomen partially yellow, at least with lateral margins partially yellow; mesonotum and mesoanepisternum yellow pilose 16

16. Abdomen with lateral margins broadly yellow and without or with very small medial yellow maculae; femora extensively yellow, with only a narrow dorsal black vitta on medial ⅔; ocellar triangle equilateral, with lateral ocellus broadly separated from eye margin, separated by about twice its diameter, with medial ocellar distance subequal to distance between lateral ocelli; hind tarsus without black bristles . . . . *brooksi*

– Abdomen with large yellow maculae at least on 2nd and 3rd terga 17

17. Hind femur yellow on basal ⅓ or more; ocellar triangle larger, with lateral ocellus narrowly separated from eye margin, separated by about its diameter 21

– Hind femur black or dark brown on basal ⅔ or more, although base maybe narrowly yellow 18

18. Fore tibia black apically, intense at least dorsally 20

– Fore tibia entirely yellow, rarely slightly darkened antero-ventrally 19

19. Occiput dorsally with row of long black pile; face profile straight; costa with golden pile restricted basally, not extending to humeral crossvein . . . . *frutetorum*

– Occiput entirely yellow pilose; face profile convex; costa with extensive golden pile basally, extending beyond humeral crossvein . . . . *versicolor*

20. Mid tibia entirely yellow; hind tibia yellow on basal ⅔ or more; fore basotarsomere without black spinules; mesonotum without medial vitta . . . . *consimilis*

– Mid tibia black on apical ¼ or more; hind tibia black basally and apically, narrowly yellow medially; fore basotarsomere with black spinules posteroventrally; mesonotum with a narrow medial pollinose vitta . . . . *rex*

21. Front narrow, about ⅙ of head width at ocellar triangle; ocellar triangle approximately equilateral, with medial ocellar distance about equal to or greater than distance between lateral ocelli; hind basotarsomere with a row of short black bristles along anterior edge; hind femur frequently black on apical ⅔ . . *flavifacies*

– Front broad, about ¼ or more of head width at ocellar triangle; ocellar triangle broader, with medial ocellar distance much less than distance between lateral ocelli 22

22. Hind basotarsomere with a double row of short black bristles along anterior edge . . . . *divisus*

– Hind basotarsomere usually without any black bristles, at most with 2–3 black bristles 23

23. Hind basotarsomere with long erect pile, at

least laterally, with pile about as long as or longer than tarsal width . . . . *integer*
– Hind basotarsomere with shorter appressed pile 24
24. Mesonotum with pollinose vittae either absent or obscure . . . . *obsoletus*
– Mesonotum with pollinose vittae distinct . . 25
25. Hind femur entirely yellow anteriorly; fore and mid tibiae entirely yellow . . . . . *kurentzovi*
– Hind femur black medially; fore and mid tibiae usually dark basally . . . . *laetus*

CHECKLIST OF *PARHELOPHILUS* SPECIES

brooksi Curran. Alberta to Wisconsin.
Parhelophilus brooksi Curran 1927: 90 ♂ Manitoba, Petchipegosis (HT ♂ CNC).
Lunomyia pollinaria Fluke 1939: 373 ♂♀ Wisconsin, Spooner (HT ♂ AMNH). Syn. Fluke 1953: 208.

consimilis Malm. Norway to western Siberia, south to France & Italy.
Helophilus consimilis Malm 1863: 80 Sweden, Stadsvassen. T ?

divisus (Loew). Michigan to Ontario, south to Indiana & Florida.
Helophilus divisus Loew 1863: 316 (1864: 200 #4:78) District of Columbia (ST ♂ MCZ).

flavifacies (Bigot). Quebec, south to Mississippi & Florida.
Helophilus flavifacies Bigot 1883: 344 ♂ Maryland, Baltimore (HT ♂ BMNH).
Helophilus anniae Brimley 1923: 278 ♂ North Carolina, Raleigh (HT ♂ USNM). **N. syn.**

frutetorum Fabricius. Scandinavia to Siberia, south to Spain, Italy, Bulgaria & Kyrghyzstan.
Syrphus frutetorum Fabricius 1775: 765 ? England (T ? Unknown, not stated in Fabricius)
Syrphus femoralis Fallén 1817: 31 ? Sweden, "in paroecia Farhult" (T ZIL)
Helophilus frutetorum var. *xanthopygus* Loew 1846: 149 Italy, Sicily, Syracuse (T ? ZMHU)

integer (Loew). Ontario & Quebec, south to North Carolina.
Helophilus integer Loew 1863: 314 ♂ New York (ST ♂ MCZ).

kurentzovi Violovitsh. Siberia, Korea, Japan.
Parhelophilus kurentzovi Violovitsh 1960: 207 ♂♀ Russia, Sakhalin, Yuzhno-Sakhalinsk (HT ♀ ZISP).
Parhelophilus obscurior Violovitsh 1960: 209 ♂♀ Russia, Sakhalin, Yuzhno-Sakhalinsk (HT ♂ ZISP). **N. syn.**
Helophilus citricornis Shiraki 1968: 214 ♂♀ Japan, Oze. (HT ♂ NIAS). **N. syn.**

laetus (Loew). British Columbia to Quebec, south to New Mexico, Louisiana & North Carolina.
Helophilus laetus Loew 1863: 315 ♂♀ New York & Wisconsin (ST ♂ MCZ).
Helophilus aureopilis Townsend 1895: 51 ♂ Michigan, Constantine (HT ♂ UKaL). Syn. Hunter 1897: 139.
Parhelophilus currani Fluke 1953: 128 ♂♀ Louisiana, 15 miles east of Creole (HT ♂ UKaL). **N. syn.**

obsoletus (Loew). Alaska to Ontario and Maine, south to British Columbia & Wisconsin.
Helophilus obsoletus Loew 1863: 314 ♂ Hudsons Bay Territory (ST ♂ MCZ).

porcus (Walker). British Columbia to New Brunswick, south to Wisconsin & Maryland.
Eumerus porcus Walker 1849: 554 ♂ Ontario, Hudson's Bay, Albany River, St. Martin's Falls (LT ♂ BMNH here designated).

rex Curran & Fluke. British Columbia to Ontario, south to Colorado & West Virginia.
Parhelophilus rex Curran & Fluke 1926: 234 ♂♀ Ontario, Macdiarmid & Algonquin Park; New York, Lake George, Northwest Bay (ST ♂ CNC).

sibiricus Stackelberg. Russia (Karelia to Eastern Siberia).
Pleskeola sibirica Stackelberg 1924: 25 ♂ Russia, "Sibiria centralis, Obj-Enisseijskij kanal. septen. et orientem versus Enisseisk" (HT ♂ ZISP). **N. comb.**

versicolor Fabricius. Scandinavia to Siberia, south to Spain, Italy, Bulgaria & Kirghiz.

Syrphus versicolor Fabricius 1794: 283 Germany (T ? Unknown, stated as "Dom. Smidt" in Fabricius)

Parhelophilus almasyi Szilady 1940: 65 Kazakhstan, Taldy-Kurgan, Panfilov (T ? MNM (destroyed?))

NOTES ON THE KEY AND SPECIES OF *PARHELOPHILUS*

Parhelophilus flavifacies is keyed in 2 couplets because the femoral tubercle can be low and difficult to distinguish in some specimens. The types of *flavifacies* and *anniae* were examined and found to represent the same species.

Parhelophilus obscurior Violovitsh and *Helophilus citricornis* Shiraki are synonyms of *kurentzovi.* I have studied the holotype of *citricornis* and Barkalov (in litt.) has studied the types of the Violovitsh species.

Parhelophilus currani Fluke is only a pale southern race of *laetus,* the few specimens of which I have seen differ from more northern ones in that the abdominal maculae are expanded and united to form fasciae.

Parhelophilus brooksi (Curran) is probably best considered a species of *Lejops (Lunomyia)* as placed by Fluke on the assumption that the lack of the apical calcar on the hind tibia is a secondary loss. The species is, however, included in the key as this is the genus in which users will probably still identify *brooksi.*

Helophilus pilosus Hunter is a species of *Lejops (Lejops),* **new combination.**

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RUDOLFINA CAVERNICOLA, A NEW SPECIES OF CAVE-ASSOCIATED SPHAEROCERIDAE (DIPTERA) FROM COLORADO AND ARIZONA

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*Abstract.—***Rudolfina cavernicola, new species,** is described from several collections from Kremmer's Cave, Colorado, and a single specimen from Arizona. Characters are given to separate the two western North American *Rudolfina.* Six species of Sphaeroceridae are listed from Kremmer's Cave, and the cave habitat is described.

Key Words: Sphaeroceridae, *Rudolfina*, caves

The genus *Rudolfina* Roháček can be recognized on the basis of the stout, upturned female cerci that are fused with the epiproct and middle part of tergite 8; the long costagial bristle; and the characteristic dark lobes of male sternite 5. There is one described Nearctic species, *Rudolfina digitata* Marshall, and one described Palearctic species, *R. rozkosnyi* (Rohacek), both of which exhibit disjunct arctic-alpine distributions (Marshall 1991). *Rudolfina* includes several undescribed southeastern Nearctic and Neotropical species, but *Rudolfina cavernicola,* new species, is closely related to the western North American *R. digitata* and the European *R. rozkosnyi.*

The cave-inhabiting Sphaeroceridae of eastern North America were discussed by Marshall and Peck (1984), who recorded 10 species of which at least one (*Spelobia tenebrarum* (Aldrich)), is a true troglobite, and at least one, *(Terrilimosina racovitzai* (Bezzi)), is a troglophile. Little is known about cave Sphaeroceridae in western North America, although one troglophilic species, *Limomyza cavernicola* Marshall, was recently described from in or near caves in Missouri, Kentucky, Oklahoma, and Colorado (Marshall 1997). Most of the type series of the new species described here, *Rudolfina cavernicola,* is from Kremmer's Cave, Colorado. *Spelobia pseudosetaria* (Duda), *Spelobia tuberculosa* Marshall, *Spelobia maculipennis (Spuler*), *Xenolimosina sicula* Marshall and *Limomyza cavernicola* Marshall were collected in Kremmer's Cave with *Rudolfina cavernicola.*

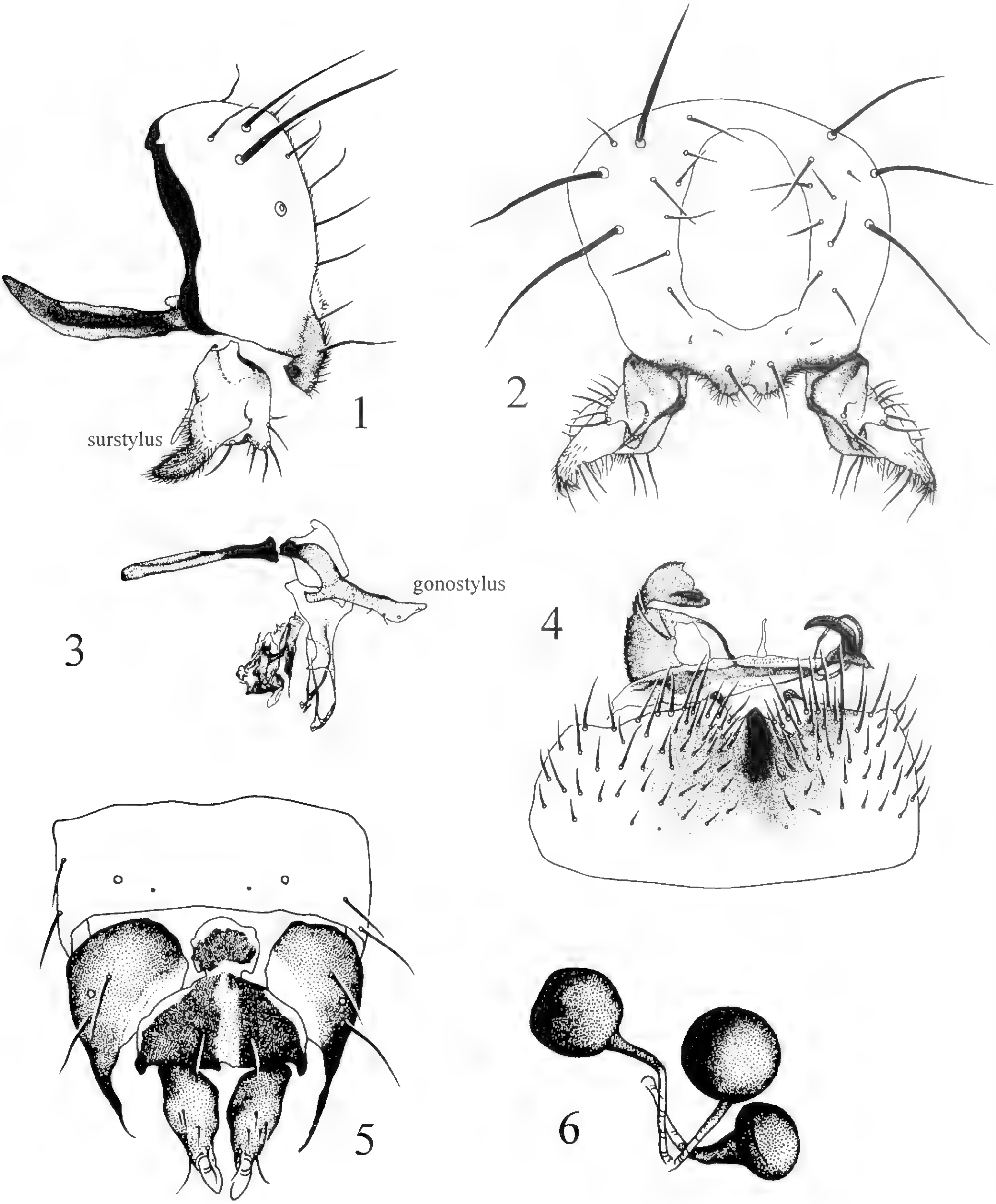
KEY TO WESTERN NORTH AMERICAN *RUDOLFINA*

- Eye height ca. 1.8× genal height. Second costal sector longer than third. Male sternite 5 with 3 posteromedial lobes, outer 2 small, equal to one another (Fig. 4). Distal lobe of surstylus setose, rounded (Fig. 1). Gonostylus expanded preapically (Fig. 3). . . . . *Rudolfina cavernicola,* new species
- Eye height ca. 1.4× genal height. Second costal sector shorter than third. Male sternite 5 with two posteromedial lobes, one bifid and one single. Distal lobe of surstylus elongate, bare, with multiple translucent lobes. Gonostylus narrow, tapered apically. . . . . *Rudolfina digitata* Marshall

Rudolfina cavernicola Marshall and Fitzgerald, NEW SPECIES

(Figs. 1–6)

Description.— Body uniformly pale brown; length ca. 2.0mm. Interfrontal plate



Figs. 1–6. *Rudolfina cavernicola.* 1–4, Male abdominal structures. 1, Terminalia, left lateral. 2, Terminalia, posterior. 3, Aedeagus and associated structures. 4, Sternites 5–7. 5–6, Female abdominal structures. 5, Tergites 7–9 and cerci. 6, Spermathecae.

equal in depth and width, bordered by 3 interfrontal bristles, the lower pair cruciate over lunule. Eye height 1.8 times genal height. Mid tibia of male slightly curved, anteroventrally with a row of short, stout bristles on distal two thirds; mid tibia of female with a single small anteroventral bristle near middle. Dorsocentral bristles in a single large prescutellar pair; 2 pairs of prescutellar acrostichal bristles, middle pair very long. Wing with costagial bristle long, longer than dorsocentral bristle; second costal sector slightly longer than third, costa ending 2–3 vein widths beyond apex of R_{4+5}.

Male abdomen: Sternite 5 with 3 posteromedial lobes (Fig. 4). Surstylus with a broad, subquadrate basal part and a narrow, setose distal part (Fig. 1). Epandrium with 3 long posterodorsal bristles on each side (Fig. 2). Subanal plate large, broadly fused; cerci small, setose. Gonostylus apically expanded, boot-shaped (Fig. 3). Distiphallus broad, complex, functional ventral surface with diverging arms, distal part of functional dorsal surface with crenulate plate on each side.

Female abdomen: Tergite 9 (Fig. 5) prolonged into a short, blunt lobe between the 2 halves of tergite 8, lobe dark and separated from rest of tergite 9 by pale area, main part of tergite 9 with a longitudinal pale strip. Sternite 7 large, dark, posterior margin spinulose; sternite 8 reduced, with 4 small, stout bristles. Sternite 9 posteromedially thin and pale. Cercus distinctly upturned, with a stout spur at apex (Fig. 5). Spermathecae round, tire-shaped; stem long.

Holotype.—♂, COLORADO. Larimer Co., 3 April, 1992, S. Fitzgerald, Kremmer's Cave, 6000′, Rt 287,6 mi N of Jct. Rt. 14. (Canadian National Collection)

Paratypes.— Colorado. Kremmer's Cave, 5,8,22.viii.1996 (1♂,2♀, 30.ix–27.x.1996; 9♂,3♀ in pit trap @85′ from entrance; 1♀ in pit trap @ 30′ from entrance; none taken in pit traps @ 9′ from entrance during same period), Scott Fitzgerald (University of Guelph and Colorado State University collections). Arizona. Hospital Flat, Pinaleno Mts., 8950′, 3.viii.1965, H. Leech (1♂, California Academy of Sciences).

Comments.—Although the male genitalia of *R. cavernicola* are strikingly different from those of *R. digitata,* the female terminalia of these closely related species are very similar in structure. Both species have a divided tergite 8, with the anterior part of tergite 9 separate from the main part of tergite 9 and between the halves of tergite 8. However, tergite 8 of *R. cavernicola* is not strongly wrinkled like that of *R. digitata,* and the spermathecae are longer. The biology of *R. digitata* is unknown, but since it has smaller eyes than those of *R. cavernicola* it is assumed that both of these species are subterranean in habit.

Kremmer's Cave is a small solution cave formed in Ingleside limestone along the east slope of the hogback in northern Colorado (Parris 1973). The cave is basically one 100 ft. long room sloping downward at about 35°. The room is largest medially, about 20 ft. wide with a 7 ft. ceiling, and narrowest near the entrance and low, terminal crawlway. The pit entrance is about 2 ft. in diameter and 3 ft. deep, and although the cave is short, it becomes cave-like (dark, humid, and of a relatively constant temperature) quickly, due to the small opening to the outside. In August the ambient air temperature taken at 25 ft. in from the bottom of the pit entrance was 42° F.

Specimens of *R. cavernicola* were collected within the first 25 ft. from the bottom of the pit entrance, henceforth referred to as the entrance-way, using an aspirator, and at 30 and 85 ft. from the bottom of the pit entrance with pitfall traps baited with slices of ripe banana. Since *R. cavernicola* was collected in sympatry with several other species of sphaerocerids, field identification was not possible and thus, the following general observations include all above mentioned species. In the entrance-way flies were observed resting or running on pieces of moist wood, among broken rock, rock pillars (probably reminiscent of the cave's discovery during a limestone mining operation (Parris 1973)), and on cave walls. Flies jumped or ran when disturbed, but were never observed to fly.

Rodent droppings, most covered with various microfungi, seem to be the most abundant food source in Kremmer's cave.

However, the nature of the pit entrance allows rain water to wash in organic debris, a minimal amount of bat guano exists near the back of the cave, and a rodent jaw bone suggests at least an occasional carcass, all of which may be possible larval food sources. As most cave-associated sphaerocerids utilize a wide range of breeding substrates (Papp and Plachter 1976), and *R. cavernicola* was apparently attracted to banana, it is probable that *R. cavernicola* is not restricted to a single food source.

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A REVIEW OF THE GENUS *HOPLISOIDES* GRIBODO (HYMENOPTERA: SPHECIDAE: GORYTINI) IN NORTH AMERICA

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Abstract.—The 30 species of *Hoplisoides* known from the continent of North America and its associated islands are described and keyed. Pertinent illustrations are given. Four new species are presented: ***H. elotae*** (Sinaloa, Mexico), ***H. niger*** (Puerto Rico), ***H. subcostalis*** (Panama), and ***H. parkeri*** (Mexico). **New synonyms** are: *knabi* Rohwer 1911 provisionally = *costalis* Cresson 1872; *maculipennis* Cameron 1890 = *iridipennis* F. Smith 1856; *umbonicida* Pate 1941 = *vespoides* F. Smith 1873. **New status** are: *hypenetes* Handlirsch 1895 as synonym of *denticulatus* Packard 1867; *birkmanni* Baker 1907 as synonym of *nebulosus* Packard 1867; *pygidialis* W. Fox 1896 as full species, not subspecies of *costalis* Cresson 1872.

Key Words: *Hoplisoides,* Sphecidae, Gorytini, North America, key

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Hoplisoides Gribodo is one of the largest genera in the tribe Gorytini with about 70 species in the World. The species of North America were keyed by W. J. Fox (1896), who recognized 9, but a little over 100 years later 30 are now known. Among the rather numerous characters of the tribe Gorytini, the following combination will identify *Hoplisoides:* forewing pictured, hindwing media diverging close to crossvein cu-a, omaulus and acetabula present, sternaulus at least partly present, propodeum punctate but without a spiracular (stigmatal) sulcus, propodeal enclosure usually with at least traces of longitudinal carinula, T-I not petiolate or pedunculate, male sterna V–VI with concealed hairbrushes.

Material studied has been about 1,000 specimens, including types, in some 30 museums in America and Europe. Muséums are listed in the Acknowledgments. This is in addition to the more than 1,500 specimens in the Bohart Museum, which has the largest and most complete collection of North American species.

Hoplisoides wasps are ground-nesting, and provision their nests with Cicadellidae or Membracidae. A detailed summary of biology was given by Bohart and Menke (1976:520).

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Academie de Sciences de Cuba	HAVANA(I)
Academy of Natural Sciences	PHILADELPHIA
American Museum of Natural History	NEW YORK
California Academy of Sciences	SAN FRANCISCO
Canadian National Collection	OTTAWA

Cornell University	ITHACA
Entomologisches Institut, Technische Höchschule	ZURICH
Gundlach Collection, Cuba	HAVANA(II)
Humboldt Museum	BERLIN
Laval University Provancher Collection	QUEBEC
Los Angeles County Museum	LOS ANGELES
Museum of Comparative Zoology, Harvard	CAMBRIDGE
Museum d'Histoire Naturelle, Switzerland	GENEVA
National Museum of Natural History	WASHINGTON
Natural History Museum, U.K.	LONDON
Naturhistorisches Museum of Austria	VIENNA
Utah State University	LOGAN
Universitets Zoologiske Museum	COPENHAGEN
University of California Bohart Museum	DAVIS
University of California Essig Museum	BERKELEY
University of Halle, Germany	HALLE
University of Lund, Sweden	LUND
University of Nebraska State Museum	LINCOLN
University of California Riverside Museum	RIVERSIDE

In the following key an important character is the nature of the metapleuron, its shape, size of its lower pit (called anteroventral metapleural pit by Bohart and Menke 1976:fig 3), and its punctation (or lack thereof). The abbreviations MOD (median ocellus diameter), F (flagellomere), T (tergum), S (sternum), and PD (puncture diameter) have been used in the keys and descriptions below. An interesting condition of most *Hoplisoides* males, and the result of considerable synonymy, is the presence of only 6 visible terga, instead of usual 7 in most gorytins, followed by an exserted S-VIII as a pseudosting. Females are easily distinguished by having a pygidial plate on T-VI, and 12 antennal segments instead of 13 in the male. In general the terminology of characters follows that described in Bohart and Menke 1976.

KEY TO THE SPECIES OF *HOPLISOIDES* IN NORTH AMERICA

Males

1\. Mesopleuron impunctate or nearly so (sometimes with a few very fine punctures) 2

– Mesopleuron punctate 6

2\. T-III unbanded 3

– T-III banded with white or yellow 4

3\. Markings yellow, propodeal enclosure with carinulae incomplete posteriorly; Cuba . . . . *ater* (Gmelin)

– Markings white, propodeal enclosure with complete carinulae; Hispaniola . . . . *alaya* (Pate)

4\. Propodeal enclosure carinulate, scutum and propodeum (posteriorly) plainly punctate . . . . *iridipennis* (F. Smith)

– Propodeal enclosure essentially smooth, propodeal punctation various 5

5\. Scutum well punctured, propodeum black and with obvious punctures posteriorly, subdiscoidal and second discoidal cells clear (based on female characters); se. U.S. and Argentina . . . . *semipunctatus* (Taschenberg)

– Scutum and posteriorly red propodeum with microscopically fine punctures, subdiscoidal and second discoidal cells stained brownish . . . . *glabratus* R. Bohart

6\. S-III to V and venter of mesothorax with dense, white, woolly pubescence, sometimes bloomlike, S-V often with a tooth or carina visible laterally 7

– S-III to V without such pubescence, no tooth on S-V 12

7\. S-V with at most a lateral denticle 8

– S-V with a definitely raised carina laterally 10

8\. Metapleural lower pit about as large as midocellus, F-VI–VIII strongly nodose beneath . . . . *floridicus* R. Bohart

– Metapleural lower pit smaller than midocellus, F-VI–VIII various 9

9\. F-VI to VII strongly thickened and nodose beneath, metapleuron usually at least partly red, pubescence of sterna bloomlike . . . . *cazieri* R. Bohart

– F-VI–VII a little thickened beneath, but not nodose; metapleuron all black; pubescence of sterna 1.0 MOD or more long laterally . . . . *denticulatus* (Packard)

10. Scutal punctures fine, mostly with diameters less than 0.25 MOD, hindfemur mostly yellow outwardly, metanotum practically impunctate . . . . *projectus* R. Bohart
– Scutal punctures moderate, many with diameters equal to 0.5 MOD, hindfemur either extensively brown or red outwardly 11
11. T-V carina rounded across top, hindfemur mostly red outwardly . . . . . *confertus* (W. Fox)
– T-V carina flat across top, hindfemur mostly brown outwardly . . . . *carinatus* R. Bohart
12. Metapleural lower pit smaller than midocellus 13
– Metapleural lower pit about as large as or larger than midocellus 20
13. Mesopleuron dentate below, metapleuron at middle narrower than 1.0 MOD, body extensively red and yellow 14
– Mesopleuron not dentate below, metapleuron at middle broader than 1.0 MOD, body various 15
14. Propodeum in posterior view red and yellow . . . . *diversus* (W. Fox)
– Propodeum in posterior view all or nearly all red . . . . *dentatus* (W. Fox)
15. Forewing with black band from wing base to apex of marginal cell, propodeal area just beyond metapleuron with series of diagonal ridges (based on female); Panama . . . . *subcostalis* R. Bohart
– Forewing without a back band from base of wing to apex of marginal cell, propodeal area just beyond metapleuron irregularly sculptured or punctate 16
16. F-I at least 2× as long as greatest breadth, metapleuron punctate, subdiscoidal and second discoidal cells each with an apical discrete cloud 17
– F-I 1.2 to 1.7× as long as greatest breadth, metapleuron not punctate, above cells not clouded 18
17. T-III–IV all or mostly dark, frons with punctation partly obscured by silvery pubescence . . . . *spendidulus* (Bradley)
– T-III–IV broadly yellow-banded (as on II, V, & VI), frons with dense punctation not obscured by pubescence; Mexico . . . . *elotae* R. Bohart
18. Propodeum usually and legs extensively red, T-VII–VIII normally visible, metapleuron tapering to a point below . . . . . *tricolor* (Cresson)
– Propodeum and legs not extensively red, spinelike S-VIII protruding from end of abdomen, metapleuron below middle mostly broader than 1.0 MOD 19
19. Last few terga broadly black, yellow bands narrow . . . . *costalis* (Packard)
– Last few terga broadly yellow . . . . *pygidialis* (W. Fox)
20. T-I–II–IV yellow banded, T-III–V–VI black, Cuba 21
– T-III yellow banded 22
21. Propodeal enclosure with carinulae quite weak or absent posteriorly; Cuba . . . . *insularis* (Cresson)
– Propodeal enclosure with carinulae all well developed; Cuba . . . . *xerophilus* Alayo
22. Scutum and mesopleuron with off-silvery or pale golden pubescence, T-II unusually broad, clypeus black . . . . *vespoides* (F. Smith)
– Scutum and mesopleuron without unusual pubescence, clypeus not usually all black . . . 23
23. Front and middle tibiae entirely yellow, pedicel bright yellow in front, yellow band of S-II mostly impunctate; Cuba . . . . . . *jibacoa* Alayo
– Front and middle tibiae not all yellow, pedicel not bright yellow dorsally, yellow band of S-II plainly punctate 24
24. Clypeus transversely bent toward apex (beveled) 25
– Clypeus not transversely bent toward apex 26
25. Clypeus sharply beveled all across, propodeal area alongside enclosure closely punctate . . . . *hamatus* (Handlirsch)
– Clypeus rounded toward middle, propodeal area alongside enclosure somewhat polished, a few punctures . . . . . . *punctifrons* (Cameron)
26. T-I–II both coarsely and rather closely punctured, PD = ⅓–½ MOD . . . . *parkeri* R. Bohart
– T-I–II or at least T-I not closely and coarsely punctured, PD = ¼ MOD 27
27. T-III to VI all or nearly all black, propodeum (except enclosure) mostly red . . . . *placidus* (F. Smith)
– T-III–IV (at least) yellow banded, propodeum not red 28
28. Submarginal cell I, discoidal cell I, and apex of medial cell all lightly clouded . . . . *placidus nebulosus* (Packard)
– Submarginal cell I, discoidal cell I, and medial cell practically clear (Mexican specimens usually with black lower edge on clypeus) . . . . *spilopterus* (Handlirsch)

Females

1. Mesopleuron impunctate or with only microscopic punctures 2
– Mesopleuron punctate 7
2. T-III unbanded 3
– T-III banded with white or yellow, at least laterally 5
3. Thorax and abdomen almost all black, T-II with traces of an apical yellow band; Puerto Rico . . . . *niger* R. Bohart
– Thorax and abdomen not nearly all black, T-I and T-IV with distinct bands 4

4\. Markings yellow, propodeal enclosure not carinulate posteriorly; Cuba . . . . . *ater* (Gmelin)

– Markings white, propodeal enclosure completely carinulate; Hispaniola . . . . . *alaya* (Pate)

5\. Propodeal enclosure completely carinulate . . . . *iridipennis* (Cameron)

– Propodeal enclosure smooth 6

6\. Antenna all yellow, frons mostly yellow, metanotum not yellow . . . . *.glabratus* R. Bohart

– Antenna black above, frons with yellow laterally, metanotum yellow; se U.S., Argentina . . . . *semipunctatus* (Taschenberg)

7\. Metapleural lower pit smaller than midocellus 8

– Metapleural lower pit about as large as or larger than midocellus 19

8\. F-I 3× or 4× as long as greatest breadth . . 9

– F-I 2× to 2.7 times as long as greatest breadth 12

9\. F-I 3× as long as greatest breadth, inner eye margins nearly parallel below, no continuous yellow or white band across summit of head, subdiscoidal cell without a discrete apical spot 10

– F-I 4× as long as greatest breadth, inner eye margins slanting slightly inward below, yellow band on summit of head continuous all across, subdiscoidal cell with a discrete apical spot 11

10\. Body mostly red, propodeum red in posterior view, tergal yellow bands present on I–III (at most) . . . . *dentatus* (W. Fox)

– Body red and yellow, propodeum mostly yellow in posterior view, tergal yellow bands on I–V (at least) . . . . *diversus* (W. Fox)

11\. Legs mostly brown; Mexico . . *elotae* R. Bohart

– Legs mostly red . . . . *spendidulus* (Bradley)

12\. Metapleuron broader than 1.0 MOD above *but* tapering to a point below, scutum and mesopleuron mostly red . . . . *tricolor* (Cresson)

– Metapleuron broader than 1.0 MOD for most of its length, scutum and mesopleuron various 13

13\. Scutum and mesopleuron mostly red, terga mostly yellow 14

– Scutum and mesopleuron mostly black, terga various 15

14\. Pygidium all red or dark red . . . . *confertus* (W. Fox)

– Pygidium yellow or at least basally yellow . . . . *.carinatus* R. Bohart

15\. T-VI densely punctured, punctured part about 1.3× as long as broad at base 16

– T-VI punctured part not densely so, about 1.9–2.2× as long as broad at base 17

16\. Legs mostly red, mesopleural punctures fine . . . . *.projectus* R. Bohart

– Legs mostly brown, mesopleural punctures moderate . . . . *.cazieri* R. Bohart

17\. Forewing with black band along costal margin to end of marginal cell, hindwing with dark cloud in basal two-thirds of medial cell; Panama . . . . *.subcostalis* R. Bohart

– Forewing without black costal band, hindwing not clouded 18

18\. T-III to V with narrow yellow bands, flagellum partly reddish beneath, pygidial carinae nearly parallel above, (T-I rarely all black) . . . . *costalis* (Cresson)

– T-III to V broadly yellow, flagellum extensively pale beneath, pygidial carinae gradually broadening above . . . . . *pygidialis* (W. Fox)

19\. T-III–IV nearly all dark, T-V–VI mostly yellow, propodeal enclosure with longitudinal carinulae disappearing posteriorly; Cuba . . . . *.jibacoa* (Alayo)

– Terga not marked as above, propodeal enclosure carinulae complete 20

20\. Subdiscoidal cell with discrete black spot apically 21

– Subdiscoidal cell without discrete spot apically 24

21\. T-III all black, or nearly so, rarely with pale marks on T-III–IV but metapleural lower pit round 22

– T-III to T-V usually pale banded, metapleural lower pit oval 23

22\. T-II black, propodeum mostly dark red; Cuba . . . . *jaumei* (Alayo)

– T-II pale banded, propodeum mostly orange red . . . . *punctifrons* (Cameron)

23\. Propodeum black . . . . . . *.hamatus* (Handlirsch)

– Propodeum (except enclosure) mostly red . . . . *.spilopterus* (Handlirsch)

24\. Pygidium with lateral carinae somewhat bent toward middle, T-II moderately punctate, many punctures more than 1.5 PD apart or more, T-VI not mostly yellow 25

– Pygidium with lateral carinae evenly curved, other characters various 26

25\. T-III to VI all or practically all black, propodeum (except enclosure) largely red . . . . *placidus* (F. Smith)

– T-III to T-V with apical yellow bands, propodeum often all black . . . . *placidus nebulosus* (Packard)

26\. T-III black or nearly so (rarely partly banded in *xerophilus*) 27

– T-III banded 28

27\. Propodeal enclosure weakly carinulate, becoming polished posteriorly, terga weakly punctured; Cuba . . . . *insularis* (Cresson)

– Propodeal enclosure completely carinulate, terga well punctured; Cuba . . *.xerophilus* Alayo

28\. Scutum and mesopleuron with off-silvery or golden pubescence, sometimes bloomlike, omaulus not continuous with sternaulus . . . . *vespoides* (F. Smith)

– Scutum and mesopleuron without such pubescence, omaulus smoothly continuous with sternaulus 29

29\. T-I–II coarsely and rather closely punctured, punctures averaging about 1.0 PD apart, T-VI–VII mostly or all yellow, submarginal cell 3 clouded over forward one-third . . . . *parkeri* R. Bohart

– T-I not evenly and coarsely punctured, T-II moderately so, other characters various . . . 30

30\. Mesopleural punctures adjacent to metapleuron medium to fine, T-II black before apical band, submarginal cell 3 clouded over about half . . . . *denticulatus* (Packard)

– Mesopleural punctures adjacent to metapleuron coarse as on rest of mesopleuron, T-II often extensively orange red in front of apical yellow band, submarginal cell 3 clouded over at least two-thirds . . . . *floridicus* R. Bohart

Hoplisoides alaya (Pate)

Psammaecius alaya Pate 1947:96. Holotype ♂, "San Domingo" (PHILADELPHIA).

Among the 6 species with a nearly impunctate mesopleuron, *alaya* is the only one with a combination of white bands on I-II–IV, and complete carinulae on the propodeal enclosure. This small species has the metapleural lower pit larger than the midocellus, and T-II is finely punctate. T-V is distinctly punctured.

The 5 ♂ and 4 ♀ I have seen were all collected on Hispaniola.

Hoplisoides ater (Gmelin)

Crabro tricinctus Fabricius 1775:375. "America". Lectotype ♂ designated by van der Vecht 1961:49 (COPENHAGEN).

Vespa ater Gmelin 1790. New name for *Crabro tricinctus* Fabricius 1775:375, preoccupied by *Vespa tricincta* Fabricius 1775:363 (now in *Sphecius*).

Vespa tristrigata Fabricius 1794:459. Lectotype ♀, "American Islands" designated by van der Vecht 1961:49.

Lestiphorus behni Dahlbom 1842:11, Holotype ♀ (LUND). Synonymy by Dahlbom 1845:483.

Harpactus scitulus Cresson 1865:147. Holotype ♀, Cuba (HAVANA-II). Synonymy by Dalla Torre 1897:555.

Although related to *alaya,* the yellow markings and posteriorly incomplete carinae of the propodeal enclosure are differentiating. I know the species only from 4 ♂ and 3 ♀ from Cuba. The female abdomen was figured by Alayo (1969). I have seen the lectotype in the Copenhagen Collection.

Hoplisoides carinatus R. Bohart

Hoplisoides carinatus R. Bohart 1968:287. Holotype ♂, Madera Canyon, Santa Cruz Co., Arizona (DAVIS).

This species is one of six that have woolly pubescence on S-III to VI of males. Three of these have an obliquely placed carina laterally on S-V. These are *carinatus, confertus,* and *projectus.* In *confertus* the carina is relatively high (about 2.0 MOD), in *projectus* lower (about 1.5 MOD) and in *carinatus* lowest (about 1.0 MOD). All three have the metapleural lower pit smaller than a midocellus, and the male flagellum only moderately swollen on F-VI–VII. In *carinatus* the punctures of the frons below the ocelli are larger, deeper, and closer than those of the other two species. Characters given for the females in the key hold fairly well.

Distribution records are from southern California (Temecula, Riverside, Big Pine), southern Arizona (Phoenix, Tucson, Pearce, Continental, Bowie, Sahuarita, Madera Canyon, Portal, Nogales), New Mexico (Rodeo); Sonora, Mexico (Cocorit, Magdalena, Santa Ana), and Chihuahua, Mexico (near Chihuahua).

Hoplisoides cazieri R. Bohart

Hoplisoides cazieri R. Bohart 1968:288. Holotype ♂, Carr Canyon, Huachuca Mts., Cochise Co., Arizona (NEW YORK).

The three *Hoplisoides* with woolly S-III to VI in the male but no definite carina on S-V are *cazieri, denticulatus,* and *floridicus.* The male of *cazieri* differs from *floridicus* by its much smaller metapleural pit, and by its smaller pleural punctures overall. From *denticulatus* it differs by its more nodose form beneath F-VI–VII. Also, *cazieri* males have no denticle laterally on S-V, whereas *denticulatus* males usually have a perceptible one. Females of the three species are not so easily separated, but characters given in the key should suffice. An interesting feature of both sexes is the partial or complete redness of the metapleuron. This is often associated with a red streak diagonally across the mesopleuron, and an extension of the yellow on T-I.

Distribution records are from Arizona (Huachuca and Chiricahua Mts.), Mexico (Jalisco, Durango, Morelos, Oaxaca, Chiapas), Nicaragua (Chinandega), and Costa Rica (Cañas). I have studied 41 ♂ and 4 ♀.

Hoplisoides confertus (W. Fox)

Gorytes confertus W. Fox 1896:525. Lectotype ♀ (seen) designated by Cresson 1928:47, "Montana" (PHILADELPHIA).

Gorytes imperialensis Bradley 1920:118. Holotype ♂ (seen), Brawley, California (ITHACA). Synonymy by Bohart in Bohart and Menke 1976:320.

The relatively high carina laterally on S-V of the male sets this species apart from its relatives, *carinatus* and *projectus.* In addition the length of the pubescence on S-VI of the male (2 to 3 MOD) is remarkable. The female is difficult to separate from that of *carinatus,* but the partly or all yellow pygidium of the latter is helpful. Females of both species have the metapleural lower pit smaller than is the case with *floridicus.* Also, the extensive red markings of the thorax differentiate *confertus* and *carinatus* from *denticulatus, projectus,* and *cazieri.*

Distribution includes California (eastern and southern), New Mexico (Tornero), Colorado (Hasty, Kit Carson), Texas (Llano Co., Alpine, Canyon, Santa Elena Canyon, Randall Co.), Oklahoma (Buffalo), Kansas (Clay Co., Scott Co., Lakin), "Montana", Nebraska (Chadron), Mexico (Samalayuca, Chihuahua, Saltillo).

Hoplisoides costalis (Cresson)

Gorytes costalis Cresson 1872:225. Holotype ♀ (seen), Texas (CAMBRIDGE).

?*Gorytes knabi* Rohwer 1911:569. Holotype ♂ (seen), Progreso, Yucatan (WASHINGTON).

Tentative new synonym.

Bohart and Menke (1976) listed *pygidialis* as a subspecies of *costalis* but I now consider it to be a valid species based on distribution and markings. At the same time they gave *knabi* species status. An examination of the holotype of *knabi,* kindly sent by A. S. Menke, leads to the doubtful synonymy above. In body structure, including the tiny metapleural lower pit, relatively simple flagellum, stout F-I, wing clouding, black clypeus, and moderately coarse punctation, *knabi* is similar to other males of *costalis* I have seen. However, on the type of *knabi* the yellow band on the metanotum and large yellow area on the propodeum posteriorly, are quite unusual.

Characteristics of *costalis* are a small metapleural lower pit, a short male F-I (about 1.3× as long as broad), a silvery pubescent male clypeus which is often all black, a coarsely punctured propodeum (except enclosure), a moderately punctured T-II, and a long narrow female pygidium (about 2× as long as broad).

The distribution is east of the 100th meridian, from New York to Nebraska and south to Missouri and Florida. Mexican localities are Vera Cruz (Cordoba), Tamaulipas (Sierra Picachoa), and Hidalgo (Actopan). H. *knabi* was from Yucatan (Progreso).

Hoplisoides dentatus (W. Fox)

Gorytes dentatus W. Fox 1893:116. Lectotype ♂ (seen), designated by Cresson

1928:47, Grand Canyon, Arizona (PHILADELPHIA).

The tooth on the lower mesopleuron is the most distinctive feature of this species as well as of *diversus*. Other characters shared by the two species are an extremely narrow metapleuron, an angled male omaulus, a short male F-I but female F-I 3× as long as broad, T-VII usually visible in males. Since both species occur in California, and Baja California Sur, Mexico, they may be conspecific. However, there seems to be a constant difference in markings, so I have kept them separate. Both sexes of *dentatus* have the propodeum red with sometimes a faint yellowish suggestion. Also, females have yellow tergal bands on I–II or rarely I–III. Females of *diversus* have the terga much more extensively yellow. Similarly, males have well formed yellow bands on I to III only.

I have seen 12 ♂ and 10 ♀ from California (Antioch, near Pearblossom, Jacumba), Arizona (near Eloy, near Sentinel), New Mexico (Las Cruces), and Mexico: Baja California Sur (near San Ignacio).

Hoplisoides denticulatus (Packard)

Gorytes denticulatus Packard 1867:430. Holotype ♂ (not female) (seen), "Louisiana" (PHILADELPHIA).

Gorytes barbatulus Handlirsch 1888:408. Syntype ♂, ♀ (studied); ♂, Illinois, Texas (GENEVA), ♀, New Orleans, (ZURICH). Synonymy by Bohart in Bohart and Menke 1976:521.

Gorytes hypenetes Handlirsch 1895:894. Syntype ♂ (seen) "Columb" and "mexicanus Laguaira" (La Guaira, Venezuela?) (BERLIN). **New status.**

I have studied Packard's type. His name apparently referred to the uneven male flagellum rather than to the denticle on S-V, as might be supposed. The species is related to *cazieri* and *floridicus*, both of which have S-III to V in males with woolly pubescence but no carina on S-V. Most males of *denticulatus* have a discernible denticle laterally on S-V. Characteristics of the species are the metapleural lower pit (slightly smaller than a midocellus), black T-II basad of yellow band, mesopleural punctures becoming 2–3 PD apart toward metapleuron. Yellow bands on T-IV–V are usually thin to moderate, but some 5 pair from Vera Cruz, Mexico are extensively yellow on T-IV to VI.

The distribution, based on 80 ♂ in the Bohart Museum collection, is mostly east of the 100th meridian (Florida, Missouri, Georgia, Illinois, Texas, Oklahoma, Nebraska, Colorado). Most Mexican states are represented as well as Costa Rica, El Salvador, and Venezuela.

Hoplisoides diversus (W. Fox)

Gorytes diversus W. Fox 1896:527. Syntype ♂, ♀ (seen), Los Angeles, California (WASHINGTON).

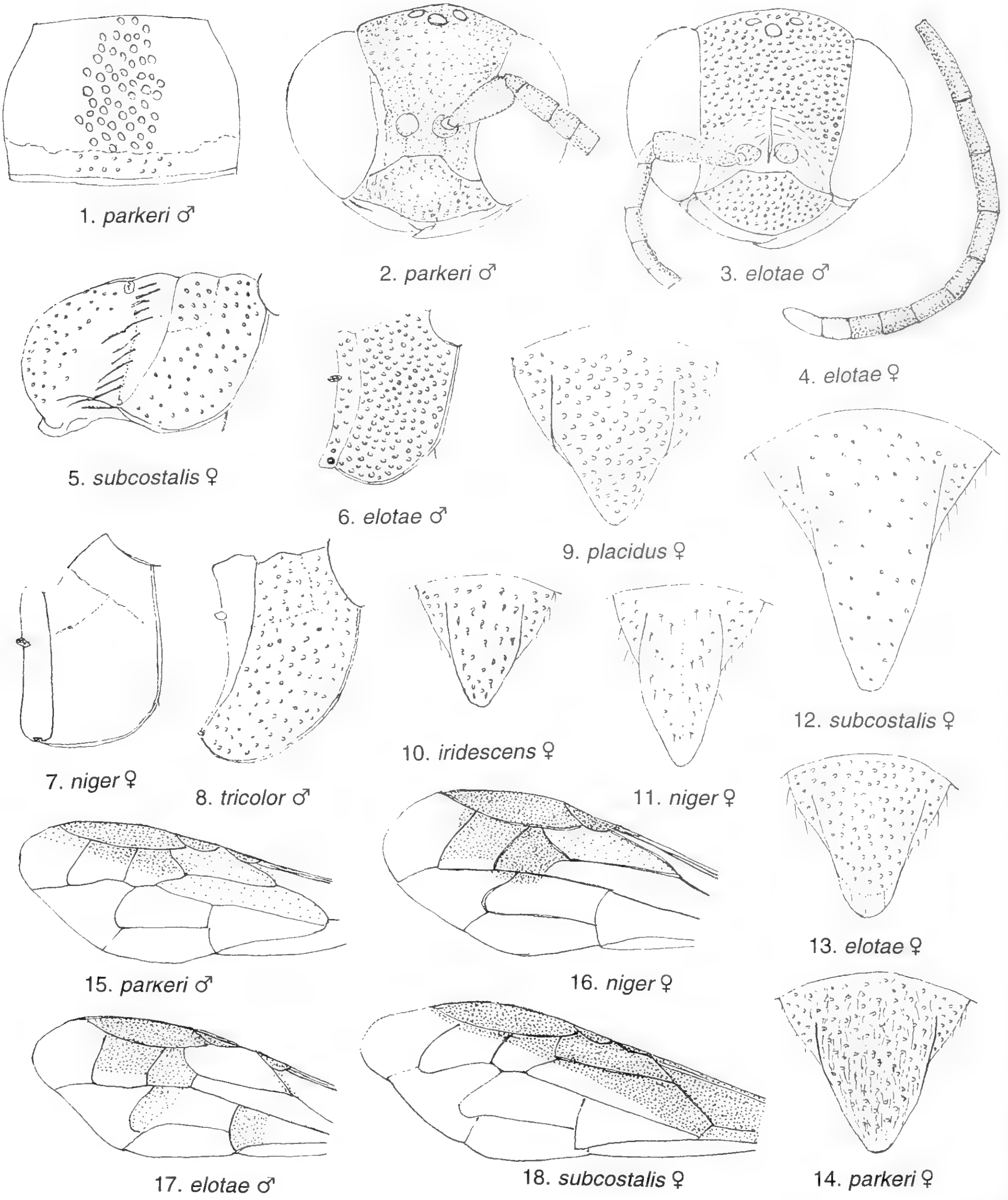
See discussion under *dentatus* and characters given in male and female keys.

I have studied 10 ♂ and 4 ♀ from California (Cawelo Jct. in Kern Co., Beaumont, Banning, Magnesia Canyon, 12 mi e. Edison, Jacumba), and Mexico: Baja California Sur (San Angel).

***Hoplisoides elotae* R. Bohart,**
NEW SPECIES

(Figs. 3, 4, 6, 13, 17)

Male holotype.—Length 7.0 mm. Black, marked with yellow as follows: pronotal ridge and lobe, fore- and midtibiae in front, apical band on T-I, broad band on T-II, T-III to VI mostly, apical band on S-II, lateral spots on S-III to V; brownish-red are: antenna in front, mediobasal spot on clypeus; brown are: legs mostly, wing spots as in Fig. 17. Pubescence inconspicuous. Punctation moderately coarse and close on clypeus, frons, vertex, scutum, propodeum, mesopleuron, and metapleuron; sparse on scutellum; punctures 1.0–2.0 PD apart on T-I–II, closer on remaining terga; coarse and close on S-II. Antenna relatively simple, F-I about 2× as long as broad (Fig. 3);



1. *parkeri* ♂
2. *parkeri* ♂
3. *elotae* ♂
4. *elotae* ♀
5. *subcostalis* ♀
6. *elotae* ♂
7. *niger* ♀
8. *tricolor* ♂
9. *placidus* ♀
10. *iridescens* ♀
11. *niger* ♀
12. *subcostalis* ♀
13. *elotae* ♀
14. *parkeri* ♀
15. *parkeri* ♂
16. *niger* ♀
17. *elotae* ♂
18. *subcostalis* ♀

Figs. 1–18. Hoplisoides species. 1, Tergum I, dorsal, punctures shown in medial area only, 25×. 2–3, Head, frontal view, 25×. 4, Flagellum, frontal view 37×. 5, Mesopleuron to propodeum, lateral, 18×. 6–8, Mesopleuron and metapleuron, lateral, 25×. 9–14, Pygidium, 30×. 15–17, Forewing, 8×. 18, Forewing, 12×.

clypeus 2× as broad as long; metapleural lower pit tiny, metapleuron breadth about 1.2× MOD (Fig. 6); T-VI angled at about 70 degrees.

Female.—Length 8 mm. Flagellum more slender, F-I about 4× as long as broad (Fig. 4), F-IX–X white in front (Fig. 4); mediobasal clypeal spot yellow, summit of head yellow all across; legs all brown; pronotum reddish, reddish spots on mesopleuron and lateroposterior propodeal area; T-I–II partly reddish, T-III to T-VI black laterally; pygidial plate with moderately fine punctation, angled at about 30 degrees (Fig. 13).

Types.—Holotype ♂ (DAVIS), 8 mi se. Elota, Sinaloa, Mexico, V-18–62 (F. D. Parker). Paratypes, 7 ♂, 1 ♀, same data as holotype.

Discussion.—As indicated in the keys, *elotae* is close to *spendidulus* and like that species has a punctate metapleuron. However, *elotae* is a much browner species, and the flagellum is stouter in both sexes.

The specific name is a noun derived from the town of Elota.

Hoplisoides floridicus R. Bohart

Hoplisoides floridicus R. Bohart 1968:289. Holotype ♂, Orlando, Florida (DAVIS).

A relationship to *denticulatus* is indicated by the woolly S-III to V in males. However, *floridicus* differs in several respects in the male. There is no trace of a lateral denticle on S-V, the metapleural lower pit is about as large as the midocellus, and F-VI–VII are nodose beneath. In both sexes the wings are extensively brownish, and the propodeum (except enclosure) is coarsely and closely punctured in posterior view. Some females resemble those of *placidus,* but the bent lateral pygidial carina of the latter is distinctive.

I have seen 7 ♂ and 26 ♀, all from Florida.

Hoplisoides glabratus R. Bohart

Hoplisoides glabratus R. Bohart 1968:291. Holotype ♂, Granite Pass, Hidalgo Co., New Mexico (DAVIS).

This little wasp is uncommonly collected. It is extensively polished and the wings are dark except for the bright yellowish stigma. Both sexes have the thorax and much of the abdomen red. The male has F-I to IV expanded beneath, but especially I and IV. The female frons and antenna are all or nearly all light yellow. Females frequent the undersides of *Bailey pleniradiata* flowers and emerge to snare leafhoppers.

I have studied 15 ♂ and 80 ♀, most which I collected at Granite Pass, New Mexico. Other records include Pearce, Willcox, Douglas, and Portal, Arizona; Deming and San Antonio, New Mexico; Colorado Springs, Colorado; Odessa and Marfa, Texas.

Hoplisoides hamatus (Handlirsch)

Gorytes hamatus Handlirsch 1888:403. Holotype ♂ (seen), "Colorado" (VIENNA).

Gorytes spilographus Handlirsch 1895:895. Holotype ♀ (seen), "Nordamerika" (GENEVA). Synonymy by Bohart in Bohart and Menke 1976:521.

Hoplisoides arizonensis Baker 1907:164. Holotype ♀ (seen), Prescott, Arizona (WASHINGTON). Synonymy by Bohart in Bohart and Menke 1976:521.

Gorytes adornata Bradley 1920:115. Holotype ♀ (seen), Felton, Santa Cruz Mts., California (ITHACA). Synonymy by Bohart in Bohart and Menke 1976:521.

Perhaps the most abundant species in California, *hamatus* is readily recognized by the sharply "beveled" male clypeus, the large oval metapleural lower pit, the discrete spot at the end of the subdiscoidal cell in the female, and the all-black propodeum.

I have studied 160 ♂ and 210 ♀ from almost every county in California from sea level to 8,000 feet in the Sierra. Out-of-state records which suggest wide distribution in western North America are: Garden of the Gods, Colorado; and Palominas and Oak Creek Canyon, Arizona.

Hoplisoides insularis (Cresson)

Harpactus insularis Cresson 1865:146. Holotype ♀, Cuba (HAVANA-II).

Characteristics are the relatively large metapleural lower pit, generally fine punctation, unbanded T-III, female F-I about 2.9× as long as greatest breadth, and sterna as well as pygidium of female red.

I have seen only a ♀ collected in Havana.

Alayo (1969) recorded 5 specimens from various Cuban localities.

Hoplisoides iridipennis (F. Smith)
(Fig. 10)

Gorytes iridipennis F. Smith 1856:363. Holotype ♀ (seen), Santarem, Brazil, (LONDON).

Gorytes fasciatipennis Cameron 1890:75. Holotype ♀ (seen), "N. Yucatan" (LONDON). Synonymy by Bohart in Bohart and Menke 1976:521.

Gorytes maculipennis Cameron 1890:73. Holotype ♀ (seen), Bugaba, Panama (LONDON). **New synonym.**

Gorytes panamensis Maidl and Klima 1939:91. New name for *maculipennis* Cameron 1890, nec Giraud 1861.

Characteristics of this wasp are: small size (about 7 mm long (male) and 8 mm (female)), nearly impunctate and polished pleuron, mostly polished T-II, metapleural lower pit oval and much larger than midocellus, T-I to V yellow banded but II to VI sometimes mostly yellow, pygidial plate well punctured and striatiform in part (Fig. 10), other features are: practically no sulcus below midocellus, mandible yellow toward base, clypeus considerably yellow, forewing costa reddish and stigma yellow, scutum moderately punctate, legs and venter partly yellow, T-III with many punctures 2 to 4 PD apart.

Of the typical sort with narrowly yellow-banded terga, I have seen 9 ♂ and 16 ♀ from Mexico (Vera Cruz, Oaxaca), Nicaragua, El Salvador, Costa Rica, Panama, Ecuador, Venezuela, Suriname, Brazil. The more extensively yellow form are 4 ♂ and 7 ♀ from Mexico (Vera Cruz, Sinaloa, Jalisco, Morelos, Oaxaca, Puebla).

Hoplisoides jaumei (Alayo)

Psammaecius jaumei Alayo 1969:17. Holotype ♀, Rangel, Pinar del Rio, Cuba (HAVANA-I). Transferred to *Hoplisoides* in Bohart and Menke 1976:521.

I do not know this species. It is included in the key on the basis of Alayo's original description of the only known specimen.

Hoplisoides jibacoa (Alayo)

Psammaecius jibacoa Alayo 1969:12. Syntype ♂, ♀, Cuba (HAVANA I).

I know this species only from the original description, and from a male syntype sent to me by Alayo. The male is black and lemon yellow, flagellum and S-III to VI all black, and clypeus finely but closely punctured. The metapleural lower pit is round and about as large as the midocellus.

The species is known only from Cuba, where it is moderately abundant.

***Hoplisoides niger* R. Bohart,**
NEW SPECIES
(Figs. 7, 11, 16)

Female holotype.—Length 8 mm. Black, marked with yellow as follows: scape in front, strip on lower frons next to eye, broken narrow band at apex of T-II; flagellum dull reddish within; wing cloud as in Fig. 16, costa black, stigma brown. Pubescence moderately appressed on clypeus, inconspicuous elsewhere. Punctation faint on frons, practically absent on polished scutum, pleuron, T-I–II, most of venter; quite fine and sparse on polished T-III to V, scattered and moderate on polished S-II and pygidial plate (Fig. 11). F-I 2.7× as long as broad; sulcus below midocellus well developed and extending one-third of distance to clypeus; forward part of scrobal sulcus two-thirds complete (Fig. 7); metapleuron mostly 1.8× as broad as MOD, metapleural lower pit oval and larger than MOD (Fig. 7), propodeal enclosure with 14 complete carinulae; T-I a little longer than broad, T-II nearly twice as broad as long; pygidial plate twice as long as broad, with a weak longitudinal median ridge (Fig. 11).

Male.—Unknown.

Type.—Holotype ♀ (WASHINGTON), Maricao, Puerto Rico, VI-20-69 (O.S. Flint, Jr.).

Discussion.—The practically impunctate pleuron, large metapleural lower pit, and complete propodeal enclosure carinulae relate this species to *iridipennis.* However, there are many differences. *Hoplisoides niger* is more extensively black and even less punctate, the midocellar sulcus is longer, the scrobal sulcus is more nearly complete, and the pygidial plate is quite different (compare Figs. 10, 11).

The specific name is a noun based on the overall black appearance.

Hoplisoides parkeri R. Bohart, New Species

(Figs. 1, 2, 14, 15)

Holotype male.—Length 7.5 mm. Black, marked with yellow as follows: central spot on clypeus, inner eye margin, apical bands on T-I to V, VI entirely, lateral dots on S-II to V; brownish are: legs, tegula, parategula; forewing with clouds as in Fig. 15. Pubescence inconspicuous, silvery, bloomlike, evident and appressed on clypeus surrounding central spot. Punctation moderate on head, coarse and close on thorax except spaced 1.0 to 3.5 PD on pleuron, coarse and 0.5–1.0 PD apart on terga (Fig. 1) and S-II, finer and more spaced on other sterna. F-I 1.5× as long as broad, F-II to X about as broad as long, F-II to VI somewhat convex beneath, F-VI to X with shiny spots beneath; metapleuron with nearly even breadth of about 1.0 MOD, metapleural lower pit about equal to midocellus, propodeal enclosure with 12 complete longitudinal carinulae, T-I slightly longer than broad, T-VI angled at about 35 degrees.

Female.—Length 8–10 mm., clypeus with more variegated markings and less pubescent than male, yellow bands sometimes present on pronotum and scutellum; pygidium as in Fig. 14.

Types.—Holotype ♂ (DAVIS), 4 mi nw. Choix, Sinaloa, Mexico, VIII-31-68 (T. A. Sears, R. C. Gardner, C. S. Glaser). Paratypes (all from Mexico): 17 ♂, 1 ♀, same data (practically) as holotype; 5 ♂, Puebla (Petlalcingo), VIII-3–63, (F. D. Parker, L. A. Stange); 5 ♂, 1 ♀, Hidalgo (Jacola), VIII-31–60 (Scullen, Bolinger); 6 ♂, Guerrero (near Chilpancingo), VIII-1962 (U. Kansas Exped.); 5 ♂, 1 ♀, Chiapas (20 mi s. Tuxtla Gutierrez), VIII-12–63 (F. D. Parker, L. A. Stange); 4 ♂, 2 ♀, Oaxaca (44 mi w. Tehuantapec), VII-21–52 (E. E. Gilbert, C. D. MacNeil). Also, non-paratypes, 13 ♂, 8 ♀ from various Mexican states including Tamaulipas, Morelos, and Zacatecas. A few specimens from Liberia in Costa Rica and Quezaltepeque in El Salvador are conspecific.

Discussion.—The close and coarse punctation of most of the thorax and abdomen, relatively unmodified male antenna, fairly large metapleural lower pit, basally black mandible, mostly brown legs, clouding over practically all of discoidal cell, and yellow markings of terga increasing toward apex, are characteristic in combination. Yellow markings vary in both sexes. Males may have narrow bands on the pronotum and scutellum. T-I may or may not be all black. Tibiae may be partly yellow.

The species is named for my friend, Frank Parker, who collected much of the type series.

Hoplisoides placidus (F. Smith)

(Fig. 9)

Gorytes placidus F. Smith 1856:368. Syntypes ♂, ♀ (seen), "East Florida" (LONDON).

Gorytes rufipes F. Smith 1856:369. Syntype ♀ (seen), "East Florida" (LONDON). Synonymy by Bohart and Menke 1976: 521.

The dark wings and extensive burnt-red coloration mark this as a typical Floridean wasp. In general it resembles *floridicus,* but the male sternal pubescence and sizable yellow bands on T-III to V of *floridicus* in both sexes are differentiating. Also, the female of *placidus* has the lateral pygidial carinae bent (Fig. 9). Other differences in both sexes of *placidus* are the larger and oval metapleural lower pit and the close, coarse punctation of the propodeum in posterior view.

I have seen 7 ♂ and 25 ♀, all from Florida.

Hoplisoides placidus nebulosus (Packard)

Gorytes nebulosus Packard 1867:424. Lectotype ♂ (seen), designated by Cresson 1928:48, "New Jersey" (PHILADELPHIA).

Gorytes armatus Provancher 1888:272. Holotype ♀ (seen), Ottawa, Canada (QUEBEC). Synonym by Bohart in Bohart and Menke 1976.521.

Gorytes microcephalus Handlirsch 1888: 405. Syntype ♂ (seen), "Georgia" (GENEVA). Synonymy by Bohart in Bohart and Menke 1976:521.

Goyrtes pergandei Handlirsch 1888:407. Syntype ♂ (seen), "Virginia and Illinois" (GENEVA). Synonymy in Bohart and Menke 1976:521.

Philanthus harringtonii Provancher 1888: 278. Holotype ♀ (seen), Ottawa, Canada (QUEBEC). Synonymy by Bohart in Bohart and Menke 1976:521.

Gorytes birkmanni Baker 1907:166. Holotype ♀ (seen), Fedor, Texas (WASHINGTON). **New status.**

Gorytes pruinosus Baker 1907:166. Holotype ♀ (seen), Fedor, Texas (WASHINGTON). Synonymy by Bohart in Bohart and Menke 1976:521.

Bohart and Menke (1976) treated *nebulosus* as a subspecies of *placidus,* and I am in agreement. Baker's *birkmanni* is an intermediate form with mostly red propodeum but wings less dark than in typical *placidus.* Males of *nebulosus* resemble those of *spilopterus,* and characters given in the key are not always satisfactory for separation. However, the bent pygidial carinae of female *nebulosus* are distinctive. Perhaps males are best separated by geography, *nebulosus* occurring east of the 100th meridian and *spilopterus* west of it.

I excavated 2 ground nests of *nebulosus* near Lake Texoma, Oklahoma. They were provisioned with many membracid nymphs, and a few adults.

I have studied 31 ♂ and 31 ♀ of this subspecies, characterized by the large oval metapleural lower pit, most terga with yellow bands, and lateral carinae of the female pygidium (T-VI) bent, rather than evenly curved (as in Fig. 9). Records cover most of the United States east of the 100th meridian.

Hoplisoides projectus R. Bohart

Hoplisoides projectus R. Bohart 1968:290. Holotype ♂, Los Banos, Merced Co., California (SAN FRANCISCO).

This species is known only from the type series, 4 ♂ and a ♀ (DAVIS), all except holotype from the San Joaquin Valley, California. It is related to *carinatus* but the eyes are farther apart in *projectus,* the mesopleural punctation finer and more spaced, and the female pygidium much more closely and rugosely punctured.

Hoplisoides punctifrons (Cameron)

Gorytes punctifrons Cameron 1890:74. Holotype ♂ (not female) (seen), Presidio, Texas (orig. "Mexico") (LONDON).

Gorytes gulielmi Viereck 1908:408. Holotype ♂ (not female) (seen), Bill Williams Fork, Arizona (LAWRENCE). Synonymy by Bohart and Menke 1976:521.

The male is somewhat like *hamatus* but *punctifrons* has the clypeus "beveled" only laterally, and the legs are more extensively red. Both species have a relatively large metapleural lower pit. The female, like *hamatus* and *spilopterus,* has a discrete dark spot at the end of the subdiscoidal cell in the forewing. However, in *punctifrons,* T-II is extensively red, and T-III to V are all black, or with remnants of bands at most. Also, the metapleural lower pit is round rather than oval as in *spilopterus.*

I have studied 67 ♂ and 60 ♀ of this relatively abundant species. The distribution covers most of the United States west of the 100th meridian. I have also seen specimens from Mexico: Sonora (Hermosillo, Magdalena) and Jalisco (Choix).

Hoplisoides pygidialis (W. Fox), New Status

Gorytes pygidialis W. Fox 1896:528. Holotype ♀ (seen), "Montana" (PHILADELPHIA).

Bohart and Menke (1976) treated *pygidialis* as a subspecies of *costalis.* I am raising it to species status since the distributions are separate, and both sexes of *pygidialis* are readily distinguished by the extensive yellow posterad on the abdomen. Also, female *pygidialis* have the pygidial plate less narrow, rather evenly expanded.

The distribution, at least in the United States, is west of the 100th meridian. The 27 ♂ and 33 ♀ studied are from: North Dakota (Slope Co.), Montana, Utah (St. George, Delta), Colorado (Palisade), New Mexico (Rodeo, Mesilla Park, Hot Springs), Arizona (Flagstaff, Portal, Bowie, Tucson, Grand Canyon, Chandler, Sedona, Nogales), California (Blythe, Ripley, Bard, Duncan, Warner Springs, Scissors Crossing, Marinette). Mexican records are: Nayarit (San Blas), Morelos (Alpuyaca), Hidalgo (Pachuca), Durango (Durango), Guerrero (Acapulco), Oaxaca (Mitla), Sinaloa (Elota, Choix), Chiapas (Tuxtla Gutierrez), Yucatan (Progreso).

Hoplisoides semipunctatus (Taschenberg)

Hoplisus semipunctatus Taschenberg 1875: 367. Holotype ♀, Mendoza, Argentina (HALLE).

It appears likely that *semipunctatus* is a South American species which has been introduced into southeastern U.S. presumably by airplane, since collections have been made near airfields. I collected females at La Cienega, Catamarca, Argentina in 1975. The main female characteristics are the nearly impunctate mesopleuron, smooth propodeal enclosure, finely punctate T-II, metapleural lower pit about as large as the midocellus, and metanotum (as well as scutellum) yellow.

Of the 33 ♀ I have studied, 8 are from Argentina (Rio Negro, Santa Fe, Cordova, Catamarca), 4 are from Brazil (Nova Teutonia, Catarina) and the others are from southern U.S. as follows: 4 from Alabama (Decator), 1 from Louisiana (Baton Rouge), 1 from South Carolina (Columbia), 1 from Mississippi (Gulfport), and 14 from Florida (Quincy, Escambia Co., Archbold Reserve).

Hoplisoides spilopterus (Handlirsch)

Gorytes spilopterus Handlirsch 1888:414. Syntype ♀ (seen), "Nevada" (VIENNA).
Gorytes pogonodes Bradley 1920:114. Holotype ♂ (seen), Lemon Cove, Tulare Co., California (ITHACA). Synonymy by Bohart and Menke 1976:521.

This abundant species in western U.S. is recognized by the relatively large and oval metapleural lower pit, the subdiscoidal cell in the female with a discrete apical spot, the mostly red propodeum (except enclosure) in the female, T-I to IV (at least) pale banded, male clypeus "beveled" but not sharply, and clear membrane of submarginal cell I, discoidal cell I, and medial cell. Males in California have the legs mostly black and yellow. Those from other western states usually have them partly red.

I have studied 70 ♂ and 90 ♀. The distribution is widespread in California at low to moderate altitudes. Records are also from Arizona, Idaho, Nevada, Utah, Wyoming, Colorado, and New Mexico, all west of the 100th meridian.

Hoplisoides splendidulus (Bradley)

Gorytes splendidula Bradley 1920:113. Holotype ♂ (seen), Brawley, California. (ITHACA).

This elegant species, with its long, slender antennae, punctured metapleuron, sharply delineated wing clouds (including a definite one in both sexes apically in the subdiscoidal cell), bloomlike pubescence on T-V, and small metapleural lower pit, are all characteristic of the similar species, *elotae*. There are a number of color differences such as in *splendidulus* the much more extensive red coloration, the all dark red T-IV–V, and the red (or yellow) frons. More important is the more slender flagellum in *splendidulus*. For example, F-IV is 1.8× (male) to 2.8× (female) as long as broad. In *elotae*, F-IV is 1.4× (male) to 1.8× (female) as long as broad.

I have studied 13 ♂ and 11 ♀ from Texas (Starr Co., Ward Co.), New Mexico (Las Cruces), Arizona (Tucson, Prescott, Grand Canyon, Yuma Co.), Utah (Nephi), Oregon (Antelope Mt., Harney Co.), California (Jacumba, Warner Springs, Brawley, Laguna Canyon, Antelope Springs, Johnsville, Tesla, Napa Co., San Diego Co., Blythe), and Mexico: Baja California Sur (San Vincente).

***Hoplisoides subcostalis* R. Bohart, NEW SPECIES**

(Figs. 5, 12, 18)

Holotype female.—Length 10 mm. Black, with yellow markings as follows: F-I to V within, scape in front, mandible toward base, clypeus partly, frons laterally, narrow band on pronotal ridge, lobe partly, narrow posterior band on scutellum, fore- and midtibiae and tarsi partly, faint apices of T-II to IV; reddish brown are: flagellum toward apex, legs mostly; pygidium dark red; forewing black across entire front (Fig. 18). Pubescence inconspicuous. Punctation practically absent on frons, moderate and 1-2 PD apart on scutum, mostly fine and widely spaced on mesopleuron, absent toward base of propodeal side, moderately coarse and close on propodeum posteriorly, fine and widely spaced on T-I–II, increasingly closer on T-III to V, coarse and moderately close on pygidium. Mandible gently curved and moderately stout (as compared with stouter one of *costalis*), posterior metapleural margin undefined but followed by a series of diagonal carinae at propodeal base (Fig. 5). Metapleural lower pit tiny; propodeal enclosure completely carinulate; forebasitarsus posteriorly black, T-I about as long as broad, T-II about 1.3× as broad as long, pygidial plate narrow overall but expanding evenly above (Fig. 12).

Male.—Unknown.

Types.—Holotype ♀ (WASHINGTON), Barro Colorado, Canal Zone, Panama, III-15–67 (R. D. Akre). Paratype, ♀ (DAVIS), topotype, IV-6–63 (C. & M. Rettenmeyer).

Discussion.—This species is related to *costalis* on the characters of the clypeal conformation, relatively large size, small metapleural lower pit, and narrow pygidial plate. On the other hand, it differs by the finer punctation of the pleuron, T-I–II, and the frons, but especially by the black anterior one-third of the forewing. The more slender mandible in *subcostalis* is also different.

Hoplisoides tricolor (Cresson)

(Fig. 8)

Gorytes tricolor Cresson 1868:380. Holotype ♀ (seen), New Mexico (PHILADELPHIA).

Gorytes helianthi Rohwer 1911:569. Holotype ♀ (seen), Boulder, Colorado (WASHINGTON). Synonymy in Bohart and Menke 1976:521.

Hoplisus rufocaudatus Mickel 1916:401. Holotype ♀ (seen), Mitchel, Nebraska (LINCOLN). Synonymy in Bohart and Menke 1976:521.

This species is characterized by the extensively red markings, especially on the legs, propodeum, and T-I (rare exceptions). Otherwise, the small lower pit at the bottom of a tapering metapleuron (Fig. 8), dark-red last two or three terga, usually exposed T-VII in the male, extensively clouded subdiscoidal cell, and broadly yellow female frons are more critical characters.

I have studied 53 ♂ and 27 ♀ from Texas (Llano Co.), Wyoming (Grand Teton Park), Colorado (Palisades, Hasty, Pueblo), New Mexico (Lordsburg, White Sands Monument, Rodeo, Correo, Granite Gap, Tucumcari, near Deming), Utah (Delta, Cornish, Salt Lake City, W. Utah Lake, Logan), Arizona (Toltec, Eloy, Willcox, Portal, Animas, Tucson, Huachuca Mts.), California (Westmorland, Tracy, Warner Springs, Elizabeth Canyon in Los Angeles Co.), Mexico: Sonora (Alamos), Sinaloa (Mazatlan, Choix), Nueva Leon (Apodaca), Coahuila (Saltillo). Except for Llano Co., Texas (99°), all of the United States localities are west of the 100th meridian.

Hoplisoides vespoides (F. Smith)

Gorytes vespoides F. Smith 1873:407. Holotype ♀ (seen), Ega (now Tefé), Brazil (LONDON).

Gorytes robustus Handlirsch 1888:380. Syntype ♀ (seen), Blumenau, Brazil (VIENNA); Tampico, Mexico (GENEVA). Synonymy by Bohart in Bohart and Menke 1976:521.

Icuma sericea Cameron 1905:21. Syntype ♀ (seen), "Panama" (LONDON). Synonymy by Bohart in Bohart and Menke 1976:521.

Gorytes auropilosellus Cameron 1912:430. Holotype ♀ (seen), "British Guiana" (LONDON). Synonym by Bohart in Bohart and Menke 1976:521.

Hoplisoides umbonicida Pate 1941:1. Holotype ♀ (seen), Caura Valley, Trinidad. (PHILADELPHIA). Callan (1976:332) suggested the synonymy. **New synonym.**

This is one of the largest species of *Hoplisoides,* females often with length of 12–13 mm. The females are robust, and most of them have T-I dark, T-II to V with apical yellow bands. Species characteristics are the relatively large oval metapleural lower pit, weak and isolated mesopleural punctures, extensive reddish brown wing coloration, becoming darker apically, T-II about 2× as broad as long, pygidial plate of female nearly 2× as long as broad, and propodeal enclosure with at least 20 carinulae but without distinct lateral boundaries.

I have studied 7 ♂ and 15 ♀ from Mexico: Chiapas (Tuxtla Gutierrez), Nayarit (near Tepic), Morelos (Alpuyeca, Cuernavaca, Lake Tequesquitengo), Guerrero (Chilpancingo), Yucatan (Chichen Itza). Specimens seen from other countries are: Guatemala (Lake Amatitlan), El Salvador (Los Charros), Panama (Potrerillos, Frejoles Canal), Ecuador (Azuay Prov., Limoncocha), Trinidad (Mundo Nuevo), Suriname (Paramaribo), Peru (Colonia Ferane), Brazil (Obidos in Pará, Itatiaya, Nova Teutonia).

Two ♀ in the collection are pinned with their prey, membracid adults, which must outweigh them.

Hoplisoides xerophilus Alayo

Psammaecius confusus Alayo 1969:14. Syntype ♂, ♀, Cuba (HAVANA I). Preocc. by Dutt 1922.

Hoplisoides xerophilus Alayo 1976:29. New name for *confusus* Alayo.

This species is known to me only by a male syntype sent by Alayo. The relatively large metapleural lower pit, completely carinulate propodeal enclosure, and unbanded T-III are distinctive in combination. The moderately punctured pleuron and T-II, particularly in the female as pictured by Alayo (1969), are additional characters. According to Alayo (1969), the species is fairly common in coastal localities of Cuba at flowers of *Coccolaba unifera.*

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LESTES JERRELLI, N. SP. (ZYGOPTERA: LESTIDAE), A NEW DAMSELFLY FROM ECUADOR

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1949 Hickory Ave., Florence, AL 35630, U.S.A.

Abstract.—**Lestes jerrelli, n. sp.**, is described and illustrated from 13 males and 8 females (holotype ♂, allotype ♀, in copula: Ecuador, Napo Prov., pond 12.3 km W of Coca, elev. 250 m, 13 June 1995). It is related to *L. jurzitzai* Muzon and *L. paulistus* Calvert from Brazil, but is distinct in thoracic color pattern and shape of male paraprocts.

Key Words: Damselfly, *Lestes jerrelli,* new species, Ecuador

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Lestes is a relatively large genus of damselflies, with about 80 species known worldwide (Bridges 1993), nearly half of these occurring in the western hemisphere. The latest description of a new species from tropical America was that of *Lestes jurzitzai* Muzon (1994) from Brazil. The new species described here was collected east of the Andes Mountains in Napo Province, Ecuador. It is mostly blue with narrow metallic green thoracic stripes, and is most closely related to *Lestes jurzitzai* based on color pattern and male appendage morphology. The new species was collected at a small pond and several small, shallow, temporary pools west of Coca, near the equator (0°27′S, 77°0′W). Aquatic vegetation varied from sparse to abundant.

Lestes jerrelli Tennessen, New Species
(Figs. 1–4, 8)

Holotype ♂: ECUADOR, Napo Province, pond along Loreto Road, 12.3 km W of junction with Coca Road, elev. 250 m, 13 June 1995, W. M. Mauffray, leg.; deposited in Florida State Collection of Arthropods (FSCA), Gainesville, Florida, USA.

Allotype ♀: in copula with holotype; deposited with holotype.

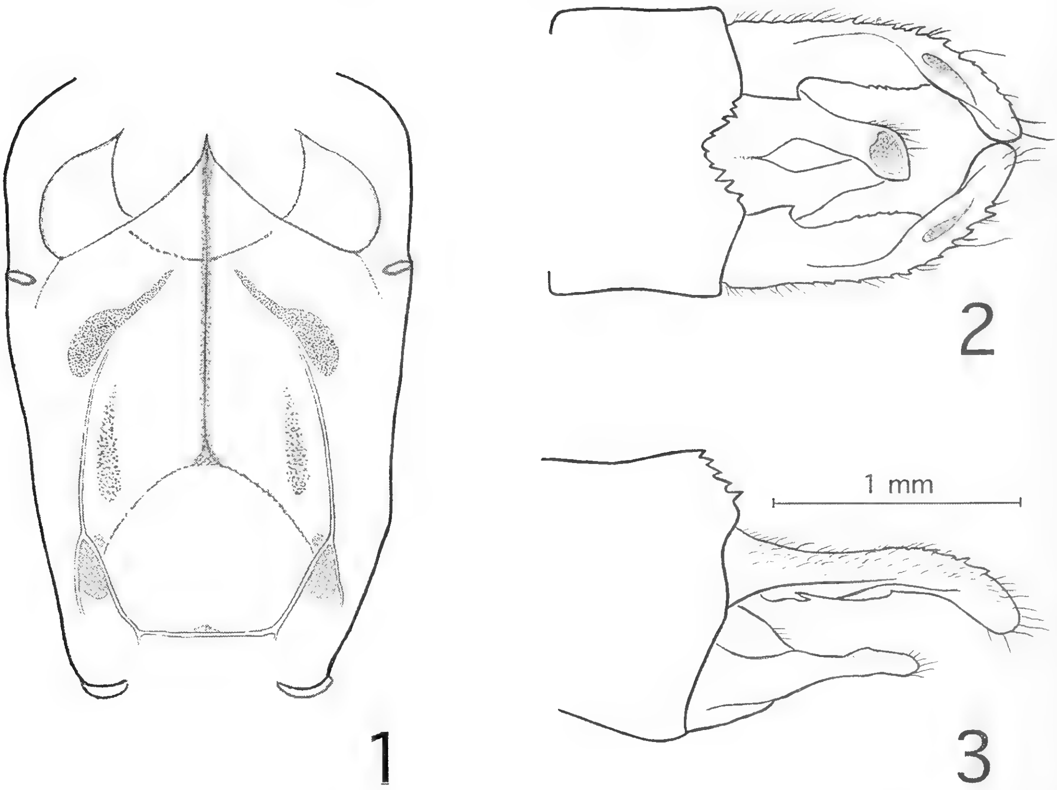
Paratypes (12 ♂, 7 ♀): Same data as holotype, 3 tandem pairs, K. J. Tennessen leg. (Coll. K. J. Tennessen); same data, 3 tandem pairs, W. M. Mauffray leg. (FSCA, International Odonatological Research Institute, Catholic Univ., Quito). ECUADOR, Napo Prov., temporary pool along Loreto Rd., 1.7 km W of junction with Coca Rd., 13 June 1995, K. J. Tennessen leg., 4 ♂, 1 tandem pair (KJT, Coll. R. W. Garrison); same data, 1 ♂, W. M. Mauffray leg., (National Museum of Natural History, Smithsonian Institution, Washington, D.C.).

Other specimens (not examined): In addition to Ecuador, *Lestes jerrelli* occurs in southern Peru: 2 ♂ in the Collection of R. W. Garrison and 2 ♂ and 1 ♀ in the National Museum of Natural History, Smithsonian Institution, are from Madre de Dios Dept., Hotel Amazonia, across from Atalaya, collected 27 June 1993.

Etymology.—This species is named for Jerrell J. Daigle in recognition of his contributions to New World odonatology and his enthusiasm for the study of dragonflies.

Holotype male.—General color pattern light blue with dark green metallic markings; eyes in life medium blue dorsally, light blue ventrally.

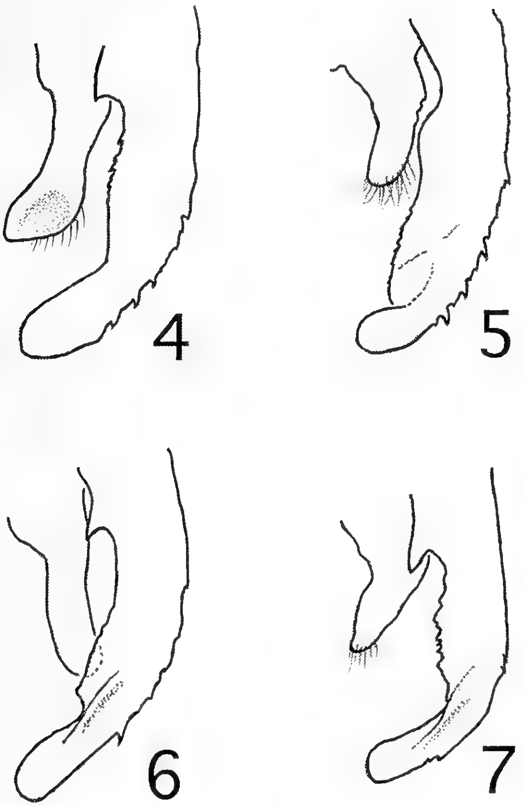
Head: Tips of mouthparts black; labrum



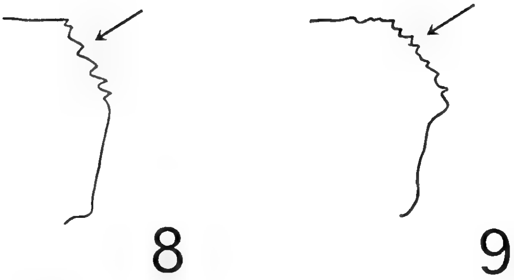
Figs. 1–3. *Lestes jerrelli,* male paratype. 1, Venter of male pterothorax. 2, Male appendages, dorsal view. 3, Male appendages, lateral view.

sky blue, distal margin black, and with a small, triangular, mediobasal black spot; base of mandible and gena blue, a lighter hue than labrum; anteclypeus mostly black, partly blue laterally; postclypeus, antefrons, antenna and postfrons black; occiput dark metallic green, with a small, blue tear-shaped postocular spot posterolateral to each lateral ocellus; rear of head greenish blue on upper half, tan near occipital foramen, black on lower half, partly pruinose.

Thorax: Prothorax largely blue dorsally, but middle lobe with a submedian pair of dark brown, outwardly curved stripes barely extending to anterior and posterior lobes, ending in small, oblong spots; epimeron 1 dark brown above, blue below. Pterothorax largely sky blue, except as follows: middorsal stripe tan blue (light blue in life), about 0.3 mm wide at midlength, narrowed at each end by adjacent metallic, dark-green dorsal (mesepisternal) stripes 0.3 mm wide, parallel sided; katepisternum 2 with upper dark brown spot; mesopleural (humeral) suture light brown, posterior to which is an isolated, metallic, dark-green stripe about 0.3 mm wide, constricted in posterior fourth; metepimeron with an anterior, black oval spot visible in lateral view and extending anteromedially as a thin line nearly to midline of thoracic venter, and with a smaller posterior black spot below posterior carina, also visible in lateral view (Fig. 1); metapostepimeron blue; thoracic venter pale tan, pruinose, and with a diffuse, narrow, dark lateral stripe on each side and along the invaginated midline anterior to poststernum. Coxae partly pruinose, pro- and mesocoxae blue and light brown, metacoxa all brown; profemur black with inner



Figs. 4–7. Left male cercus and paraproct, dorsal view. 4, *Lestes jerrelli*, Peru, Madre de Dios Dept. 5, *Lestes pictus*, Brazil, Santa Catarina State. 6, *Lestes jurzitzai*, Brazil, Rondônia State. 7, *Lestes paulistus*, Brazil, Santa Catarina State. (Figs. 4–7 drawn by R. W. Garrison.)



Figs. 8–9. Posterior margin of male abdominal segment 10, Dorsolateral view. 8, *Lestes jerrelli*, Ecuador, Napo Prov. 9, *Lestes jurzitzai*, Brazil, Rondônia State. (Fig. 9 drawn by R. W. Garrison.)

surface pale tan in basal half, meso- and metafemora mostly black but with tan stripes on dorsal and ventral surfaces; tibiae black except extensor surfaces tannish blue; tarsi and claws black. All tergal and axillary sclerites blue; wings hyaline, with 13 or 14 postnodal crossveins in fore wing, 12 in hind wing; pterostigma dark brown, surmounting 2 cells, 1.40 mm long in hind wing.

Abdomen: (Abdominal segments designated with an S and a number, e.g., S1 = segment 1). S1 blue with very small submedian and sublateral dark spots, posterolateral and ventral carinae black; S2 blue with elongate dorsolateral dark metallic green stripe about 0.4 mm wide, not reaching posterior margin of segment; S3 about 2.3 times as long as S2; S3 to S7 largely dark metallic green, S3 with narrow blue basal ring, S4 to S7 with small, blue, basolateral triangles, these connecting to ventrolateral blue stripes anteriorly and tan stripes posteriorly; S8 with narrow, dark basal ring, S8 and S9 pruinose, dark brown dorsally, reddish brown laterally; posterior margin of S10 with dorsal, stout, black spines (Figs. 2, 8). Cercus black, about 1.5 times longer than S10, in lateral view decurved in apical fourth (Fig. 3), in dorsal view curved inwardly (Fig. 2), outer margin with numerous stout spines, elongate dorsal subapical concavity present, basal tooth sharp, quadrate, ventromedial lobe slightly convex with about 6 to 8 small marginal teeth and a few smaller denticles; paraprocts black, in lateral view straight (Fig. 3), in dorsal view relatively stout (0.14 mm wide at narrowest point), directed inward and expanded at tip, dorsal surface of tip with shallow depression (Fig. 2).

Measurements (mm): Total length (including cercus) 40.0, abdomen length 32.0, hind wing length 21.2.

Allotype female:—Color pattern similar to male, blue hue less intense; other differences noted below.

Head: Labrum without mediobasal black spot; postclypeus dark brown; base of antenna and segments 1 and 2 partly tan; median ocellus surrounded by narrow tan marking, lateral ocelli with oblong tan spot laterally.

Thorax: Prothorax greenish blue; pterothorax with blue area more extensively invaded by tan than in male; legs with pale stripes wider and longer than in male; wings with 13 postnodal crossveins in fore wing, 12 in hind wing; pterostigma 1.50 mm long.

Abdomen: S7 about 2.5 times as long as S8; apical segments darker than in holotype, S8 with dorsomedial, light brown oval spot; posterolateral corner of basal plate of ovipositor truncate; gonostyle 0.48 mm long; tips of ventral valves extending to posterior margin of S10; cercus 0.60 mm long, about 3/4 length of S10.

Measurements (mm): Total length (including cercus) 37.3, abdomen length 29.2, hind wing 21.7.

Variation in paratypes.—*Male:* labrum sky to medium blue, mediobasal black spot oval or triangular; katepisternum sometimes entirely blue; post-mesopleural metallic green stripe sometimes interrupted in apical fourth; wings sometimes slightly flavescent; 12 to 15 postnodals in fore wing, 11 to 15 in hind wing; pterostigma 1.15–1.40 mm long; S1 sometimes without small black spots. Total length 38.0–41.0 mm; abdomen length 30.5–33.0 mm; hind wing length 19.6–22.3 mm. *Female:* labrum sometimes with mediobasal black spot; wings usually flavescent; 12 to 14 postnodals in fore wing, 11 to 14 in hind wing; pterostigma 1.40–1.55 mm long; posterolateral corner of basal plate of ovipositor sometimes acutely angulate; cercus 0.56–0.62 mm long. Total length 36.0–39.5 mm; abdomen length 28.0–30.7 mm; hind wing length 21.0–23.3 mm.

COMPARISON WITH OTHER SPECIES

Lestes jerrelli belongs to a small group of South American species that have bright blue markings which includes *L. jurzitzai* and *L. paulistus* Calvert (1909) from Brazil, *L. pictus* Hagen in Selys (1862) from Brazil and Argentina, and *L. debellardi* De-Marmels (1992) from Venezuela. In *L. pictus* and *L. debellardi,* the male cercus lacks a basal tooth (Fig. 5), and the paraproct is only about half as long as the cercus. *Lestes jerrelli* differs from *L. jurzitzai* and *L. paulistus* by the tips of the paraprocts being expanded and dorsally excavated (Figs. 2, 4); in most specimens of *L. jerrelli,* the tip of one of the paraprocts overlies the other. In dorsal view, the paraprocts of *L. jurzitzai* are parallel-sided and curve outward slightly (Fig. 6), whereas those of *L. paulistus* are acuminate, shorter, and angled inward (Fig. 7). The dorsal, posterior margin of abdominal segment 10 bears larger, stout spines in *L. jerrelli* (Fig. 8) compared to *L. jurzitzai* (Fig. 9). The dark thoracic stripes and anterior abdominal markings of *L. jurzitzai* are black (Muzon 1994); these markings in *L. paulistus* were black in specimens examined by Muzon (1994), although a male in the Collection of R. W. Garrison has metallic green thoracic stripes (personal communication). All specimens of *L. jerrelli* I examined have dark-green metallic thoracic stripes. In *L. jerrelli,* the dark-green stripe posterior to the mesopleural suture is complete at its anterior end, whereas in *L. jurzitzai* this stripe is interrupted anteriorly (see Muzon 1994, Fig. 1a); also in *L. jurzitzai,* the mesepisternal dark stripe has a lateroventrally directed arm at its posterior end. The color pattern on the venter of the pterothorax in *L. jerrelli* is similar to *L. jurzitzai* and *L. pictus* (see Calvert 1909, Plate 1, Fig. 11). However, Calvert's figure of *pictus* shows that the metepimeral black spot in *L. pictus* is not elongated into a narrow, anteromedially-directed stripe as in *L. jurzitzai* (see Muzon 1994, Fig. 1B and *L. jerrelli,* Fig. 1).

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SYNONYMY OF TWO GENERA (*EUMAYRIA* AND *TRISOLENIELLA*) OF CYNIPID GALL WASPS AND DESCRIPTION OF A NEW GENUS, *EUMAYRIELLA* (HYMENOPTERA:CYNIPIDAE)

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Abstract.—The genus *Trisoleniella* Rohwer and Fagan is a **new synonym** of *Eumayria* Ashmead. A redescription of *Eumayria* and a key to species are given. Species included in *Eumayria* are: *E. bignelli* (Dalla Torre and Kieffer), **n. comb.;** *E. brevicornis* (Beutenmueller), **n. comb.;** *E. enigma* (Weld), **n. comb.;** *E. floridana* Ashmead; and *E. saltata* (Ashmead), **n. comb.** *Eumayria enigma* is probably the unisexual generation of *E. floridana.* Two species previously placed in *Eumayria* are transferred to other genera: *E. longipennis* (Ashmead) to *Andricus* (**n. comb.**) and *E. invisa* (Weld) to *Eumayriella* (**n. comb.**). ***Eumayriella,* n. gen.,** is described to include ***E. archboldi,* n. sp.,** and *E. invisa,* and it is compared to the closely related genus *Eumayria.*

Key Words: cynipoids, gall wasps, taxonomy, morphology, distribution, biology

The diagnostic features currently used in the keys to North American oak cynipid genera of the tribe Cynipini frequently include morphological characters that are variable and consequently are unable to distinguish different genera. These systematic difficulties are the outcome of using inappropriate diagnostic characters for some genera. The presence or absence of a tooth of the tarsal claws is the main diagnostic character used to divide all the Cynipini into two large generic groups and the current systematic arrangement of the tribe is based primarily on this characters (Weld 1952a). Ashmead (1886), in his earlier key to the genera of the Cynipidae did not use this criterion; however, his later generic key included this characteristic (Ashmead 1903). This morphological criterion is insufficient for all taxonomic distinctions. The presence or absence of tooth on the tarsal claw is likely a homoplasy and probably evolved independently in several Cynipini genera. The ancestral condition is probably the simple tarsal claw since it appears in the majority of genera from the Aylacini. The authors will analyse this character in detail in another work.

Furthermore, the nomenclature used to describe taxonomically important structures in publications prior to the 1960s is inconsistent (Dailey and Menke 1980). Various authors have used different terminology to define the same morphological structure and have employed the same term for different structures. As a consequence, species have been misunderstood and misidentified.

Four species of *Eumayria* Ashmead were known, all from the United States: *E. eldoradensis* (Beutenmueller), *E. floridana* Ashmead, *E. invisa* Weld, and *E. longipennis* (Ashmead). *Eumayria eldoradensis* was transferred into *Callirhytis* previously (Dailey et al. 1974), while *E. longipennis* herein is transferred to *Andricus.* A comparison of the morphological criteria designated earlier as diagnostic for the separation of *Eumayria* and *Trisoleniella* and an analysis of the types of *Eumayria* and *Trisoleniella* species, indicate that the two genera are synonyms. *Trisoleniella* included the unisexual generations, while *Eumayria* contained the bisexual ones. Weld (1952a) wrote that *Trisoleniella* "may prove to be asexual form of *Eumayria*". Consequently, the four known species of *Trisoleniella: brevicornis* (Beutenmueller), *enigma* (Weld), *bignelli* (Dalla Torre and Kieffer), and *saltata* (Ashmead) are transferred to *Eumayria.* Furthermore, an examination of the morphological characteristics of the only known brachypterous species, *E. invisa,* showed marked differences from those of *E. floridana* as well as other known *Trisoleniella* species. These differences indicate that *E. invisa* and *E. archboldi,* (new species), must be separated into a new genus *Eumayriella.*

We follow the current terminology for morphological structures (Eady and Quinlan 1963, Fergusson 1995, Gibson 1985, Menke 1993, Ritchie and Peters 1981, Ronquist and Nordlander 1989). The term "thorax" used here includes the propodeum and thus is equivalent to the "mesosoma" or "mesosoma+metasoma" of American literature. Abbreviations for fore wing venation follow Ronquist and Nordlander (1989). Measurements and abbreviations used here include: F1–F12, 1st and consequent flagellomeres; POL (post-ocellar distance) is the distance between the inner margins of the posterior ocelli; OOL (ocellocular distance) is the distance from the outer edge of a posterior ocellus to the inner margin of the compound eye.

Eumayria Ashmead

Eumayria Ashmead 1887: 147; Ashmead 1903: 153. Type species: *Eumayria floridana* Ashmead, by monotypy.

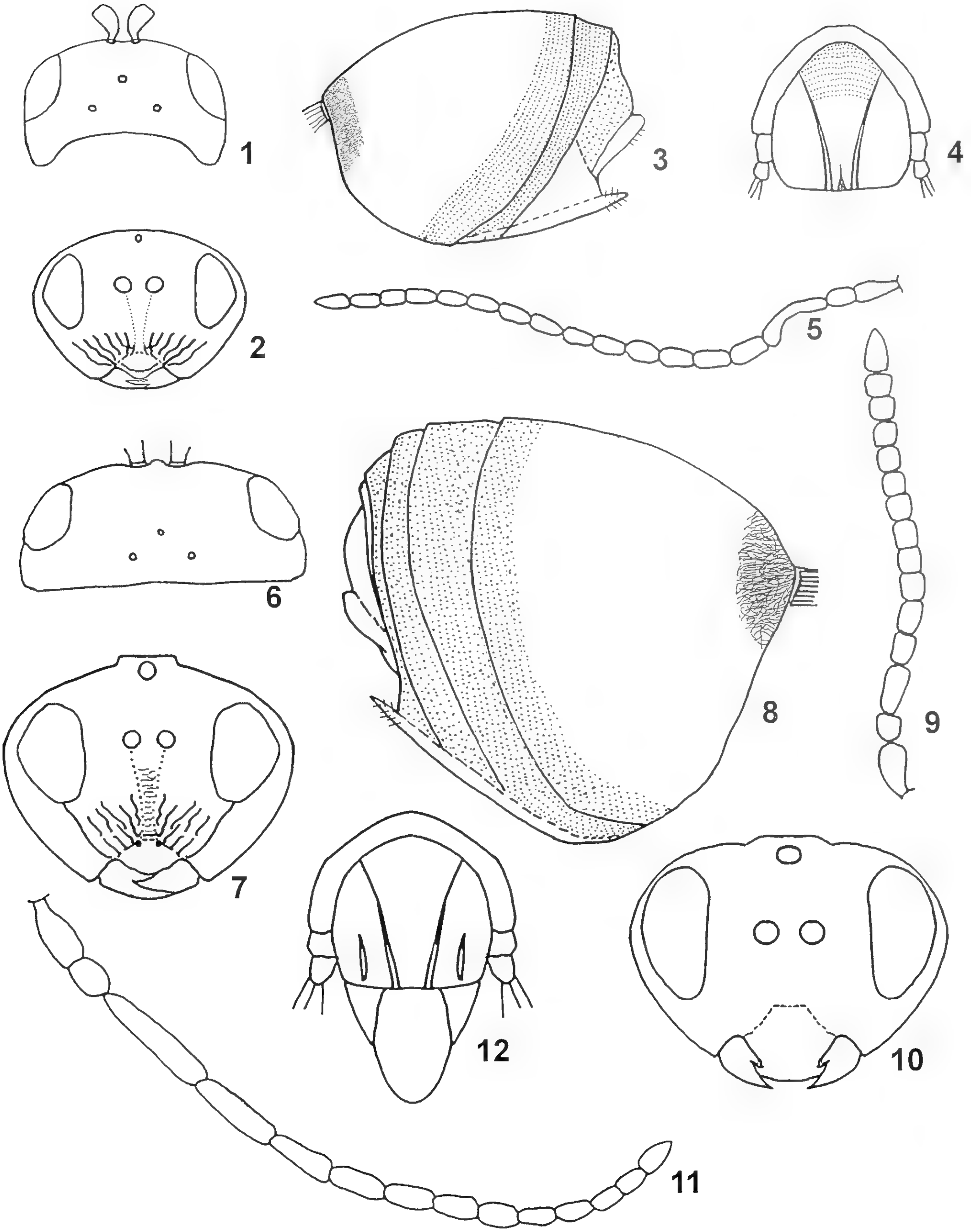
Trisolenia Ashmead 1887: 142: Ashmead 1903: 155; Dalla Torre and Kieffer 1910: 453 (as synonym of *Andricus* Hartig). Type species: *Andricus saltatus* Ashmead, by monotypy. Preoccupied by *Trisolenia* Ehrenberg 1861 in Protozoa. **New synonymy.**

Trisoleniella Rohwer and Fagan 1917: 377. New name for *Trisolenia* Ashmead.

Comments.—The original descriptions of *Eumayria* and *Trisoleniella* were made by Ashmead (1887). However, these descriptions lack sufficient precision and detail and do not include some important diagnostic characters. Some of the characters used in Ashmead's generic descriptions are found in other genera as well. Too much attention was paid to the description of antennae of males and females while important characters of the head and thorax were not mentioned. Finally, a redescription of the genus is necessary in order to set new limits for the genus because of synonymization of *Trisoleniella* to *Eumayria.*

Diagnosis.—Head 1.5–1.7 times broader than long from above in bisexual generation and 2.5–2.8 times broader than long in unisexual females; malar groove absent. Thorax flattened dorsoventrally, not arching in anterior part; scutum slightly longer than broad, finely coriaceous or macroscopically punctate, never transversely sculptured. Base of 2nd abdominal tergite with pale felt-like ring of dense short setae, interrupted dorsally (in males dense short pale setae present only ventrally and ventroaterally). See also the diagnostic criteria of *Eumayriella* below.

Redescription.—Female. Head from above equal or broader than thorax; 1.5–1.7 times broader than long from above in bisexual females (Fig. 1) and 2.5–2.8 times broader than long in unisexual females (Fig. 6); in front view head 1.2–1.3 times broader than high. Gena broadened behind eye, equal or broader than cross diameter of eye. POL and OOL nearly equal. Occiput and vertex finely coriaceous, while frons and gena dull rugose, frons with uniformly distributed short white setae. Malar space slightly shorter than length of eye, without groove, but with numerous striae radiating



Figs. 1–12. 1–5, *Eumayria floridana*. 1, Head from above. 2, Head in front view. 3, Gaster of female in profile. 4, Thorax in dorsal view. 5, Male antenna. 6–9, *E. enigma*. 6, Head from above. 7, Head in front view. 8, Gaster of female in profile. 9, Antenna. 10–12, *Eumayriella archboldi*. 10, Head in front view. 11, Antenna. 12, Thorax in dorsal view.

from mouthparts into malar space and frons (Figs. 2, 7); striae more distinct and thicker in former *Trisoleniella* than in *Eumayria floridana.* Antenna 14-segmented in bisexual females and 15–16-segmented in unisexual females; in some *E. floridana* specimens, suture separates 15th segment. F1 as long as pedicel, scape as broad as long; F2 to F4 slightly longer than broad, subsequent flagellomeres, except last one, subequal, nearly as broad as long (Fig. 9). Pronotum in median dorsal line longer than usual, with two very dense patches of white short setae on both sides of median dorsal line, collar of pronotum not emarginated, lie in same range as scutum, much broader than usual for Cynipini (Fig. 4), and longitudinally rugose. Scutum bare, very slightly longer than broad, finely alutaceous or macroscopically punctate, never transversely sculptured; notauli usually reaching pronotum; parapsidal, anterior parallel and median lines present, latter distinct at least over posterior two thirds. Scutellum bare, equal or very slightly longer than broad, rounded posteriorly, disk dull rugose; foveae deep, with shiny, more finely sculptured bottom. Mesepisternum longitudinally rugose, posterior third smooth, shiny, with very finely rugose sculpture. Propodeum with smooth, bare and shiny median portion limited by distinct carinae, converging slightly outwards in the middle. Sides of propodeum bearing dense white setae. Fore wing margins without cilia, veins thick, dark brown, areolet indistinct, very small, triangular. Base of 2nd abdominal tergite with pale felt-like ring of dense short setae, interrupted dorsally. In *E. floridana* gaster longer than high, 2nd abdominal tergite occupies at least ⅚ of gaster length in dorsal view; only posterior ⅓ to ¼ finely punctate while remainder smooth (Fig. 3). In former *Trisoleniella* species gaster nearly as long as high or only very slightly longer, 2nd abdominal tergite occupies only ⅔ of gaster length and finely punctate (Fig. 8) (shape of gaster could depend on size of egg mass). Ventral spine of hypopygium narrow, longer than broad, never reaching beyond apex of gaster, with very few short scattered pale setae never reaching beyond apex of spine. Unisexual females larger than bisexual ones.

Male. Only known male is that of *E. floridana.* Antenna 17-segmented (in some specimens indistinct suture suggests 18th segment), first three segments flattened, F1 slightly longer than pedicel and scape together, strongly curved and enlarged posteriorly. All subsequent flagellomeres, except last one, nearly of same length, slightly longer than broad (Fig. 5). Fore wing margins with cilia, veins thick and brown. Gaster as long as head and thorax together; 2nd abdominal tergite occupies entire length of gaster, subsequent tergites hidden under it. Otherwise, males similar to females.

Distribution.—Eastern and midwestern United States. Three species are known only from Florida: *E. floridana, E. enigma,* and *E. saltata. Eumayria brevicornis* and *E. bignelli* are known from New York and New Jersey; the galls they induce are unknown.

Biology.—*Eumayria floridana* is known only from a bisexual generation and induces stem swelling-like galls, while the four other species have only unisexual generations.

KEY TO SPECIES OF *EUMAYRIA* AND *EUMAYRIELLA*

1. Fully winged; 2nd abdominal tergite with felt-like ring of dense short pale setae at base, interrupted dorsally 3
– Brachypterous females; without ring of dense short pale setae at base of 2nd abdominal tergite 2
2. Frons without or with very few short scattered white setae; scutum and scutellum slightly elongated; notauli reaching pronotum; F1 equal or slightly longer than pedicel and scape together; small species, length 2.3–3.2 mm. . . . . *Eumayriella invisa* (Weld)
– Frons with dense white, long setae; scutum and scutellum rounded, nearly as broad as long; notauli present at least in posterior half, the sculpture of scutum hidden under dense white pubescence; F1 distinctly longer than pedicel and

scape together; larger species, length 4.0–5.2 mm. . . . . *Eumayriella archboldi,* n. sp.
3. Male; F1 curved and broadened in its posterior half . . . . *Eumayria floridana* Ashmead
– Female 4
4. Head broader than thorax, 1.5–1.7 times broader than long from above; scutum finely alutaceous; antenna 14-segmented; small species . . . . *Eumayria floridana* Ashmead
– Head as broad as thorax, 2.5–2.8 times broader than long from above; scutum finely alutaceous or densely macroreticulate; antenna 14–16-segmented; large specimens, at least 4–5 mm. in length; 5
5. Antenna 14-segmented; scutum densely and uniformly punctate; body black or dark brown . . . .*Eumayria brevicornis* (Beutenmueller)
– Antenna 15–16 segmented 6
6. Antenna 15-segmented; known to induce root galls . . . . *Eumayria enigma* (Weld)
– Antenna 16-segmented 8
8. Scutum very finely and uniformly coriaceous . . . . *Eumayria saltata* (Ashmead)
– Scutum with much more dull sculpture at basal end . .*Eumayria bignelli* (Dalla Torre and Kieffer)

Eumayria bignelli (Dalla Torre and Kieffer), New Combination

Trisolenia punctata Ashmead 1896: 129. Preoccupied in *Andricus* by Bignelli 1892. Types examined.

Andricus bignelli Dalla Torre and Kieffer 1902: 61. New name for *Trisolenia punctata* Ashmead.

Amphibolips montana Beutenmueller 1913a: 122; Weld 1951: 644 (synonym of *punctata*). Type examined.

Trisoleniella punctata: Weld 1951: 644 (secondary homonym).

Diagnosis.—Closely resembles *E. saltata* in having 16-segmented antenna, however, basal end of scutum with duller sculpture than that of *E. saltata.*

Distribution.—New York, New Jersey.

Biology.—Unisexual females only are known. The galls and the host associations are unknown.

Eumayria brevicornis (Beutenmueller), New Combination

Andricus brevicornis Beutenmueller 1913b: 245. Type examined.

Trisoleniella brevicornis: Weld 1951: 644.

Diagnosis.—Closely resembles *E. saltata* and *E. enigma,* however, antenna 14-segmented while in *E. enigma* and *E. saltata* antennae 15–16 segmented; scutum densely and uniformly punctate; body black or dark brown.

Distribution.—New Jersey.

Biology.—Unisexual females only are known. Galls are unknown. Observed ovipositing in the buds of *Quercus alba* L. (Beutenmueller 1913b).

Eumayria floridana Ashmead

Eumayria floridana Ashmead 1887: 133, 147. Females, males, galls. Types examined.

Eumayria multiarticulata Ashmead 1887: 133 (name proposed unnecessarily; description of galls according to those of *E. floridana*); Dalla Torre and Kieffer 1910: 601; Weld 1921: 230 (as a synonym of *E. floridana*); Burks 1979: 1107 (in unplaced species of Cynipoidea).

Diagnosis.—Head broader than thorax, only 1.5–1.7 times broader than long from above, antenna 14-segmented, while in all other species of genus head as broad as thorax and 2.5–2.8 times broader than long from above, and antenna 15–16 segmented. On basis of galls only, difficult to distinguish from some *Loxaulus* galls and those of *Bassettia floridana.* Typically galls of *E. floridana* are larger swellings than those produced by above-mentioned species. Reared adults and knowledge of host oak are critical to correct identification.

Distribution.—Indiana, Illinois, Arkansas, Texas, Virginia, Florida.

Biology.—Only a bisexual generation is known. Induces stem-swelling galls at the base of young sprouts of *Quercus coccinea* Muench., *Q. falcata* Michx., *Q. ilicifolia* Wangenh., *Q. incana* Bartr., *Q. laurifolia* Michx., *Q. myrtifolia* Willd., *Q. rubra* L., *Q. texana, Q. velutina* Lam. (Weld 1921, 1959). Adults emerge in May through August.

Eumayria enigma (Weld), New Combination

Callirhytis enigma Weld 1921: 219. Females and galls. Types examined.
Trisoleniella enigma: Weld 1951: 644.

Diagnosis.—Similar to *E. saltata,* however female antennae with 15 and not 16 segments. Location of galls and host oaks different for the two species.

Taxonomic comments.—Morphological characteristics of the adults suggest that *E. enigma* could be a unisexual generation of *E. floridana.* It differs from *floridana* in that the head as broad as the thorax, while in *floridana* the head is broader than the thorax. The only other morphological differences between these two species are the number of antennal segments (14 in *E. floridana* and 15 in *E. enigma*), and the shape of the gaster and particularly that of the 2nd abdominal tergite. Otherwise they are identical.

Distribution.—Illinois, Texas, Virginia, Louisiana, Florida.

Biology.—Unisexual females only are known. Induce root galls on *Quercus laevis* Walt., *Q. myrtifolia, Q. nigra* L., *Q. rubra, Q. texana* (Weld 1921, 1959). Adult emergence date is unknown. Adults can be dissected from galls by the beginning of November in Florida (Weld 1921).

Eumayria saltata (Ashmead), New Combination

Andricus (Trisolenia) saltatus Ashmead 1887: 142. Females and galls. Types examined.
Trisolenia saltata: Ashmead 1903: 155.
Andricus saltatus: Dalla Torre and Kieffer 1910: 549.
Trisoleniella saltata: Weld 1951: 644.

Diagnosis.—The galls are very specifically shaped, easily distinguished by the gall alone. For adults, see the key to the species and diagnosis of *E. bignelli, E. brevicornis.*

Distribution.—North Carolina, Florida (Jacksonville, Ocala - Weld 1926, 1951).

Biology.—Unisexual females only are known. Induces bud galls on *Quercus falcata* (Weld 1951), *Q. laevis, Q. incana* (Ashmead 1887; Weld 1951, 1959), *Q. rubra* (Weld 1926). Galls in March - April, adults in April (Ashmead 1887, Weld 1926).

Species Transferred from *Eumayria*

Andricus longipennis (Ashmead), New Combination

Neuroterus longipennis Ashmead 1887: 140. Type examined.
Eumayria longipennis: Weld 1951: 644.

Comments.—The type for this species is a male and bears the labels "Jacksonville, Fla.", "Collection Ashmead", red label "Type No. 2873 USNM", and a handwritten label "*Neuroterus longipennis* Ashm." Ashmead described the female and the gall "from eight specimens bred May, 1886" (Ashmead 1886). The description, given by Ashmead (1887) does not agree with this specimen. Yet, this is the only specimen of this species that we were able to find in the USNM collection. However, L. Weld indicated in his personal catalog (a copy of which was kindly sent to us by Dr. R. J. Lyon) that, in addition to the type, there were two wasps and one gall in an old case in the USNM and that the collection of American Entomological Society had 3 wasps. In his catalog L. Weld wrote: "Type in USNM has head massive, not broadened behind eyes, no malar groove, ant. 16-seg. . . ."—these characters were the basis on which Weld moved the species into *Eumayria.* The term "head from above massive", which Weld (1952) defined as a head with a "length at least half width" from above, is too imprecise for taxonomic purposes. For instance, there are bisexual *Andricus* species (*A. crispator* Tschek, *A. quercuscalicis* Burgds, *A. quercuspetiolicola* (Bass.)) and several North American *Callirhytis* species known to have "massive head", 1.8–2.0 times only broader than long. A precise ratio of length and width must be given to avoid confusion. *Eumayria floridana* has a head only 1.5–1.7 times broader than long, which can never be found in *Andricus* or *Callirhytis* species. The two other characters—genae not broadened behind eyes, no malar groove—are present in many genera. Antenna of the male of *N. longipennis* type is 16-segmented, while in *E. floridana* it is 17- or even 18-segmented. The presence or absence of the tooth on tarsal claws, as we mentioned above, is likely a homoplasy; consequently, it is a character of no generic importance. An examination of *Neuroterus longipennis* type (male) showed that it is not a *Eumayria* species. It belongs instead to the genus *Andricus* in a group of species known to induce stem-swelling galls. Several North American species from the current *Callirhytis* genus eventually must be transferred to this group as well.

Distribution.—Florida (Jacksonville) (Ashmead 1887, Weld 1951).

Biology.—Only the male is known. Induces stem-swelling galls (Ashmead 1887) on *Quercus laurifolia* (Ashmead 1887) and *Q. phellos* L. (Weld 1959). Adults emerge in May.

***Eumayriella* Melika and Abrahamson, NEW GENUS**

Type species.—*Eumayria invisa* Weld (1952b). Holotype (No. 60123) and six paratypes in the USNM [examined].

Etymology.—The genus is named in honor of Dr. Gustav Mayr.

Diagnosis.—Fore wing never reaching beyond apex of gaster. Closely resembles brachypterous species of *Trichoteras* Ashmead: *T. coquilletti* Ashmead and *T. tubifaciens* (Weld). However, in *Eumayriella,* thorax flattened dorso-ventrally; pronotum dorsally much longer, placed in same plane as scutum; scutum and scutellum pubescent, each longer than broad, scutoscutellar suture distinct, scutellum without foveae; head broader than thorax from above, 2.3–3.0 times broader than high; antenna filiform, F2 shorter than F1; while in *Trichoteras* thorax arched in anterior one-third; pronotum dorsally much shorter and not in same plane as scutum; each scutum and scutellum as long as broad; head narrower or equal to thorax; antennae short, F2 nearly equal F1. *Eumayriella* also closely resembles *Eumayria,* but head more transverse in front view and from above (2.3–3.0 times broader than high, while in bisexual *Eumayria* only 1.5–1.7 times and in unisexual *Eumayria*—2.5–2.8 times; malar space without radiating striae; antenna filiform, long, 14-segmented, F1 substantially longer than pedicel and scape together; all flagellomeres much longer than broad. Scutum and scutellum longer than broad, with dense white setae, without median and anterior parallel lines; distinctly emarginated laterally and partially posteriorly too; scutellum without foveae, with transverse depression along scutoscutellar suture; apical one-third of scutellum gradually depressed toward apex and narrowed into point that joins scutum along median dorsal part; while posterior one-third of scutellar disk highest part, strongly convex; sculpture of scutellar disk very finely punctate, posterior one-fourth rugose. In *Eumayria* head nearly as high as broad, malar space and partially frons with radiating striae; antennae much shorter, F1 as long as pedicel, scape as broad as long; F2 to F4 slightly longer than broad, subsequent flagellomeres, except last one, subequal, nearly as broad as long; scutellum with foveae, posterior part of disk never convex; posteriorly rounded and with dull rugose sculpture; scutum and scutellum bare, without dense white setae. Second abdominal segment in *Eumayriella* without pale felt-like ring of dense short setae at base, while *Eumayria* with such ring. Last character also used for separation of several genera of Eucoilidae (Cynipoidea) (Quinlan 1986).

Description.—See descriptions of *E. invisa* and *E. archboldi.*

Distribution.—Florida.

Biology.—Only females are known.

Galls in a form of chambers, hidden under the bark of twigs.

Eumayriella archboldi Melika and Abrahamson, New Species
(Figs. 10–12)

Description. Unisexual female. Entire body red brown, except for black proepisternum and propodeum. Head from above much broader than thorax, 3 times broader than long; in front view transverse (Fig. 10). Occiput, vertex, gena, and frons uniformly finely punctate, frons with dense short pale setae. POL only slightly longer than OOL; gena broadened behind eye, nearly as broad as diameter of eye; malar space uniformly finely punctate, without groove and radiating striae; nearly 4 times shorter than length of eye; clypeus depressed, rounded anteriorly. Antenna long, filiform, 14-segmented in holotype, however indistinct suture in paratypes suggests 15th segment. Pedicel and scape flattened, F1 longer than pedicel and scape together, subsequent flagellomeres distinctly longer than broad, gradually shortened toward end (Fig. 11). Pronotum in median dorsal line longer than usual, only 7 times shorter than length of scutum; in same range as scutum, not arched. Sides of propodeum densely pubescent, distinctly visible dorsally, much broader than usual in Cynipini (Fig. 12). Scutum smooth, shiny, with areas very finely coriaceously sculptured, especially laterally, densely pubescent; as broad as long, with notauli reaching pronotum (in type specimen) or present at least in posterior two thirds. Scutum without median and anterior parallel lines; emarginated laterally. Scutellum emarginated posteriorly and laterally, with very indistinct foveae; finely coriaceous, densely pubescent, distinctly longer than broad; posterior one-third of scutellar disk highest part, strongly arched. Fore wing narrow, barely reaching apex of gaster, with thick brown veins, with cilia on margins. Legs slightly lighter than body, uniformly brown. Propodeum black, median part shiny, bare, with strong striae, limited by two distinct carinae converging gradually and slightly inward. Gaster slightly longer than high, base of 2nd abdominal tergite without ring of pale setae, occupying nearly half length of gaster; 3rd to 6th tergites visible and finely punctate dorsally and dorsolaterally. Ventral spine of hypopygium very slightly reaching beyond apex of gaster, narrow, needle-like, with very few and short pale setae, never reaching beyond apex of spine. Length 3.1–3.6 mm.

Diagnosis.—Frons with dense white long setae while in *E. invisa* without/or with barely visible, very few, short scattered pale setae. Scutum rounded, nearly as broad as long; notauli present at least in posterior half, sculpture of scutum hidden under dense white pubescence while in *E. invisa* scutum slightly elongated, notauli distinctly reach pronotum. F1 much longer than pedicel and scape together, while in *E. invisa* F1 equal or only slightly longer than pedicel and scape together and body much smaller than in *E. archboldi.*

Types.—Holotype ♀. Paratypes two ♀. *Type locality.* Archbold Biological Station, Lake Placid, Highlands Co., FL, adults trapped on 4 January 1988 (coll. Mark Deyrup). Holotype in the USNM, Washington, DC, 2 paratype ♀ in the private collection of G. Melika.

Etymology.—The species named in the honor of Mr. Richard Archbold, founder of the Archbold Biological Station.

Distribution.—Florida (Archbold Biological Station, Lake Placid, Highlands Co.).

Biology.—Only females are known. Adults emerge in December–January.

Eumayriella invisa (Weld), New Combination

Eumayria invisa Weld 1952b: 335. Females and galls. Types examined.

Diagnosis.—See diagnosis to *E. archboldi.* Difficult to distinguish this species on the basis of galls alone. Galls similar to those caused by *Callirhytis crypta* (Ashm.), *Bassettia floridana.* Adult wasps are necessary for precise identification.

Comments.—We do not provide a description of *E. invisa* because it was described precisely by Weld (1952a).

Distribution.—Florida (Carrabelle-type locality-Weld 1952b; Archbold Biological Station, Lake Placid, Highlands Co.; Jonathan Dickinson State Park, Martin Co.).

Biology.—Only a unisexual generation is known. Induces stem galls in the form of small larval cells hidden under the bark, usually without external evidence of galling on *Quercus myrtifolia.* Adults were dissected from galls in November (Weld 1952b). Adults emerge in January in south-central Florida (personal observation).

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SEXUAL DIMORPHISM IN MOUTHPARTS OF *BLEPHARONEURA* LOEW (DIPTERA: TEPHRITIDAE)

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Abstract.—Adults of *Blepharoneura manchesteri* Condon and Norrbom (Tephritidae), which rasp and feed upon living plant tissues, are sexually dimorphic in number and distribution of robust blade-like pseudotracheal ring tips (= blades). Both sexes have similar numbers of pseudotracheae, but labella of females have more than twice as many blades as males. Such sexual dimorphism in labellar rasping surface may be associated with higher nutritional requirements of females. Although sex differences in nutritional requirements have been reported for other tephritid fruit flies, ours is the first report of sexual dimorphism in pseudotracheal characters.

Key Words: labella, phytophagy, fruit flies, Cucurbitaceae

Adult fruit flies in the genus *Blepharoneura* Loew (Tephritidae) abrade and break plant surfaces and feed on released substances. This behavior, unknown in any other fly, varies among species of *Blepharoneura.* Some species feed on surfaces of young leaves, leaving distinctive patterns of lacy holes, while others feed on the tips of pedicels (following abscission of flowers), or on the surface of fruit, leaving distinctive traces as scars on the fruit surface (Condon and Whalen 1983; Condon and Norrbom 1994). While feeding, the abdomen of the fly becomes swollen with fluid the color of the tissue being rasped. Distinctive morphological characters are associated with this behavior (Driscoll and Condon 1994).

Labella of *Blepharoneura* bear rows of blade-like pseudotracheal ring tips (=blades) in a rasp-like arrangement (Driscoll and Condon 1994). Unlike most flies, *Blepharoneura* have rows of two kinds of labellar pseudotracheal rings and ring tips: rows of open rings with brush-like tips, which form the channel-like pseudotracheae that deliver liquid to the mouth as in most flies (Elzinga and Broce 1986); and rows of highly modified closed rings with blade-like tips, which are offset from and parallel to the channel-like pseudotracheae. Blade-bearing rings are fused along the length of the blades, suggesting that the modified rings function as braces for blades that rasp surfaces of plants (Driscoll and Condon 1994). These distinctive blades are a synapomorphy of the clade (which includes *Blepharoneura* and two poorly known Old World genera, *Hexaptilona* Hering and *Baryglossa* Bezzi) that may be the most basal clade of the Tephritidae (Condon and Norrbom 1994; Han and McPheron 1994).

As a first step toward understanding the functional significance of labellar blades and associated feeding behaviors, we looked for evidence of sexual dimorphism in mouthparts. If blades are used to obtain secondary

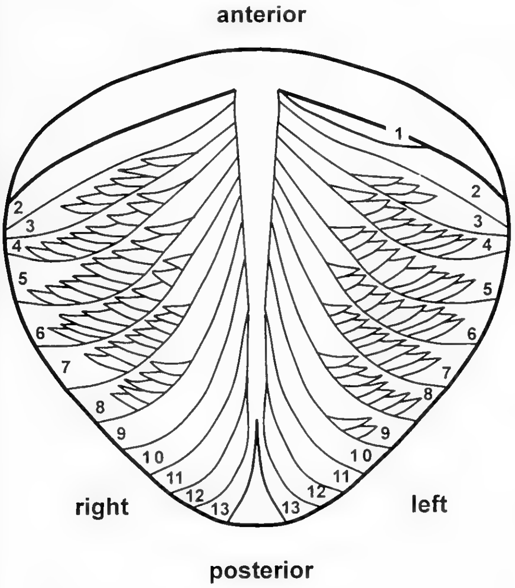

Fig. 1. Arrangement of pseudotracheae and blade-like pseudotracheal ring tips (blades) on the labella of *Blepharoneura* sp. (drawing based on female specimen F3, see Table 1). To emphasize blades, brush-like pseudotracheal ring tips are not shown. Labella are shown in the open position in which they contact surfaces of plants. Pseudotracheae are numbered from anterior to posterior.

compounds used by males in courtship, we expected males to have proportionately more blades than females. Alternatively, if nutrients or other chemicals obtained during adulthood are used in egg production (Tsitsipis 1989; Hendrichs et al. 1993), we expected females to have more blades than males. To test these hypotheses, we examined male and female specimens of *Blepharoneura manchesteri* Condon and Norrbom, a species that feeds on surfaces of fruit of *Gurania spinulosa* Cogn. (Cucurbitaceae) in northern Venezuela.

MATERIALS AND METHODS

Using specimens of *B. manchesteri* reared from seeds of *G. spinulosa* collected in Guatopo National Park in northern Venezuela, we followed slightly modified techniques of Driscoll and Condon (1994) to prepare labella. We soaked heads of specimens in distilled water for 2–3 days, then boiled specimens briefly in dilute solutions of KOH or NaOH. After boiling specimens in distilled water, we allowed the water to cool to room temperature, and added a few drops of formaldehyde to the cooling water. Once mouthparts were everted, we prepared specimens for SEM using hexamethyldisilanzane (HMDS). Dried specimens were sputter coated with 16 nm of gold and examined with a Hitachi 2460-VP scanning electron microsope.

Beginning with the most anterior pseudotracheae, we counted and numbered pseudotracheae on each labellar surface, and counted blades on each pseudotrachea (Fig. 1). We rotated specimens to get accurate counts because mouthparts were not always evenly everted.

RESULTS

Labella of male and female specimens of *B. manchesteri* differ strikingly in the number and distribution of blades (Fig. 2, Tables 1, 2). Despite small sample sizes, we found statistically significant differences between males and females in number of pseudotracheae with blades, number of blades per pseudotrachea, and total number of blades on labella (Table 2). Females had nearly three times as many blades (92–102) as males (31–44), and blades were located along twice as many pseudotracheae. Males and females differed not only in absolute numbers of blades, but also in proportion of pseudotracheae associated with blades: blades were associated with an average of 48% of pseudotracheae in females, and 23% in males (Table 2). Males and females did not differ significantly in total number of pseudotracheae (Table 2).

In both sexes, blades were concentrated among the more anterior pseudotracheae (Fig. 1; Table 1). In males, blades occurred exclusively along anterior pseudotracheae: all posterior pseudotracheae in males were brush-bordered (i.e. bladeless). In females, blades occurred along no more than a third of the posterior pseudotracheae. In both sexes, the posterior

Table 1. Distribution of blades along pseudotracheae of individual specimens of *Blepharoneura manchesteri*. Pseudotracheae are numbered from anterior to posterior (see Fig. 1). A dash indicates absence of a pseudotrachea. R = right labellum. L = left labellum. Specimens are identified by a number preceded by F (female) or M (male). To highlight anterior to posterior asymmetry of blade distribution on labella, **bold type** indicates presence of blades; a line indicates the halfway point, half of the pseudotracheae are above (anterior) to the line, and half are below (posterior) to the line.

Female Specimens

Pseudotrachea	F3		F9		F38		F45	
	L	R	L	R	L	R	L	R
#1	0	—	0	—	0	0	0	—
#2	0	0	0	0	0	0	0	0
#3	**3**	**6**	**9**	0	**8**	0	0	0
#4	**8**	**8**	**9**	**5**	**10**	**11**	0	**7**
#5	**9**	**9**	**8**	**10**	**12**	**10**	**9**	**10**
#6	**9**	**9**	**8**	**11**	**12**	**13**	**11**	**12**
#7	**9**	**8**	**7**	**11**	**8**	**10**	**12**	**8**
#8	**7**	**5**	**4**	**9**	**5**	**6**	**9**	**9**
#9	**2**	0	0	**7**	0	0	**8**	**7**
#10	0	0	0	**1**	0	0	**5**	0
#11	0	0	0	0	0	0	0	0
#12	0	0	0	0	0	0	0	0
#13	0	0	0	0	—	—	0	0
#14	—	—	0	0	—	—	0	0
#15	—	—	—	—	—	—	0	0
Total	47	45	45	54	55	50	54	53

Male Specimens

	M10		M19		M35		M37	
	L	R	L	R	L	R	L	R
#1	0	0	—	0	0	0	—	0
#2	0	0	0	0	0	0	0	0
#3	0	0	0	0	0	0	0	0
#4	0	0	0	0	**6**	0	0	0
#5	**5**	**2**	**9**	**7**	**8**	**8**	**7**	**4**
#6	**7**	**7**	**8**	**8**	**5**	**7**	**5**	**6**
#7	**6**	**6**	**6**	**6**	0	**4**	**4**	**5**
#8	0	0	0	0	0	0	0	0
#9	0	0	0	0	0	0	0	0
#10	0	0	0	0	0	0	0	0
#11	0	0	0	0	0	0	0	0
#12	0	0	0	0	0	0	0	0
#13	0	0	0	0	0	0	0	0
#14	0	0	—	—	—	—	—	—
Total	18	15	23	21	19	19	16	15

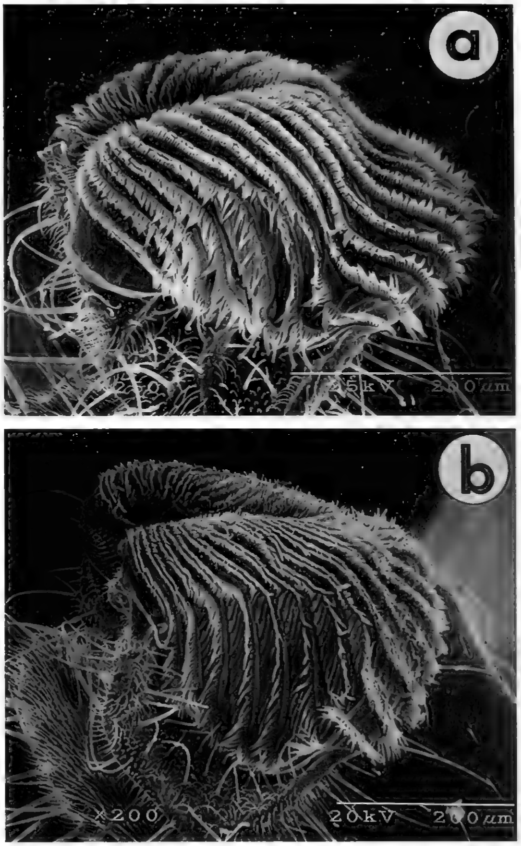

Fig. 2. *Blepharoneura manchesteri*, right labella of male (a, specimen F38) and female (b, specimen M19) specimens (see Table 1). Labella are swollen beyond the "normal" contact position so that all pseudotracheae are visible. Pseudotracheae without blade-like pseudotracheal ring tips (= blades) are bordered on either side by brush-like pseudotracheal ring tips (= brushes). These brush-bordered pseudotracheae are densest posteriorly. Mop-like brushes also occur medially (toward the prestomum) on both sides of pseudotracheae that bear blades. Along the portion of the pseudotrachea where blades occur, brushes are present only along the posterior margin. Posterior and medial arrangements of brushes suggest that brushes function as mops that sop up liquids released by damaged plant tissue.

portion of the labella usually bears at least 50% more brush-bordered (i.e., bladeless) pseudotracheae than the anterior portion of the labella (Table 1).

DISCUSSION

We found significant sexual dimorphism in number and distribution of blades on la-

Table 2. Sexually dimorphic traits of labella of *Blepharoneura manchesteri*. Summary statistics (Mann Whitney U test) for samples described in Table 1: * = $P < .05$, ** = $P < .025$.

Trait	Male N = 4		Female N = 4		
	Mean	Range	Mean	Range	*P*
Number of pseudotracheae (both labella)	26	25–28	26.3	25–29	NS
Number of pseudotracheae with blades (both labella)	6	6	12.25	11–13	**
% pseudotracheae with blades	23%	21–24%	48%	41–52%	**
Mean number of blades per pseudotrachea with blades	6.1	5.3–7.3	8.3	7.1–9.6	*
Maximum number of blades per pseudotrachea	7.8	7–9	11.25	9–13	*
Total number of blades	36.5	31–44	100.7	92–107	**

bella of *B. manchesteri* (Fig. 2; Tables 1,2). Although both male and female flies rasp plant surfaces, the greater number of blades in females suggests that they are able to cause more damage to a greater surface area of plant tissue than males. The anterior concentration of blades and brushes in both males and females suggest that the mechanism of rasping is similar for males and females (Table 1). The anterior portions of the labella probably make contact with the plant surface first and are moved forward so that tips of blades contact plant tissue. In both sexes, the brush-like pseudotracheal ring tips, which are densest nearest the mouth and along the more posterior pseudotracheae, probably act as mops to sop up fluids released by abraded plant tissues (Fig. 2).

That females have more blades than males is consistent with the hypothesis that the unusual plant-rasping behavior of *Blepharoneura* is associated with different nutritional requirements of males and females. Nutritional requirements of males and females are known to differ in some economically important tephritids (Tsitsipis 1989). In some tephritids, ingestion of nutrients other than carbohydrates during adulthood appears to be necessary for production of eggs, but not spermatazoa (Hendrichs et al. 1991, 1993). Because *Blepharoneura* rasp plants in the Cucurbitaceae, which often contain cucurbitacins— highly bitter compounds (Tallamy and Krischik 1989), rasping behavior also could be associated with aquisition of secondary compounds that could be used as defenses of larvae or adults.

Are *Blepharoneura* the only tephritid fruit flies with sexually dimorphic labellar surfaces? Despite evidence for sexual differences in nutritional requirements in economically important tephritids, little is known about the functional morphology of their mouthparts. Mediterranean fruit flies (*Ceratitis capitata* (Wiedemann)) have blade-like pseudotracheal ring tips like those of *Blepharoneura,* but the blades are smaller and the blade-bearing pseudotracheal rings are open (like most flies) not highly modified as in *Blepharoneura* (Driscoll and Condon 1994). In contrast to *Blepharoneura* and *Ceratitis, Anastrepha, Bactrocera,* and *Rhagoletis* lack "blades" and have a scalloped arrangement of pseudotracheal ring tips that may function as filters, not rasps (Elzinga and Broce 1986; Driscoll and Condon 1994). We could not find any studies reporting sexual dimorphism (or lack of) in labellar surfaces of other tephritids. Further study of labellar morphology and feeding mechanisms could lead to improvements in pest control programs that target foraging adults, particularly females (Rössler 1989).

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FOUR PUZZLING NEW SPECIES OF MECOPTERA

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Abstract.—New genus ***Eremobittacus*** and new species ***Eremobittacus spinulatus*** (Mexico), ***Nannobittacus dactyliferus*** (Eucador), ***Panorpa sentosa,*** and ***Panorpa truncata*** (Mexico) are described and illustrated. The unusual characteristics of each species are discussed.

Key Words: Mecoptera, Panorpidae, Bittacidae

For several years, the species discussed here have remained unnamed and undescribed in the hope that additional specimens would be found, of these or closely related species, that would help to clarify their relationships with others in their respective genera. This hope, however, has not been realized. Each of the four species possesses a striking peculiarity that sets it uncommonly far apart from its supposedly nearest relatives. In one case, it was not possible to assign the species to any existing genus. The unique and puzzling structural characters are discussed following the description of the respective species.

Holotypes, allotypes and most paratypes are in the Snow Entomological Collection, Natural History Museum, University of Kansas, Lawrence, Kansas.

Venational abbreviations, other than the usual ones of the Comstock-Needham system, are as follows: Scv—subcostal cross-vein from Sc to R, ORs—origin of Rs from R, FRs—first fork of Rs, Pcv—pterostigmal cross-vein(s), OM—origin of M from Cu_1, FM—first fork of M.

Eremobittacus Byers, NEW GENUS

Similar in many characteristics to *Bittacus* but differing in (1) length of hind basitarsus compared to that of fourth tarsomere, (2) wing venation, (3) surface sculpture and (4) body colors. In hind tarsus, basal segment approximately same length as fourth and shorter than second and third together. Cross-veins between R_4 and M_4 in transverse-diagonal alignment; these outer three ranks of cross-veins crossing five cells and conspicuously bordered by clouding darker than wing membrane generally. Hairs on most body surfaces very short and arising from apices of microscopic spinules (Fig. 7), but spinules much more numerous than those bearing hairs (especially noticeable on generally glossy hind femora). Colors contrasting, particularly on legs (Fig. 6); not seen in other regional Bittacidae.

By existing keys, *Eremobittacus* will be identified as the Australian *Harpobittacus* because of the relative lengths of the hind tarsomeres. Transverse-diagonal alignment of most major cross-veins into three ranks is not unique (occurs rarely in *Bittacus*) but is conspicuous in *Eremobittacus* due to dark coloring along these cross-veins. Presence on much of the body surface of tiny subconical denticles, or spinules (Fig. 7), has not been seen elsewhere in the Bittacidae. Mexican species of *Bittacus* are rather uniformly brown or yellowish brown and do not have the contrasting coloration as in *Eremobittacus.*

Type species: Eremobittacus spinulatus, new species.

Etymology: The generic name is from the Greek words *eremos,* solitary or lonely, and its derivative *eremia,* desert or wilderness, plus *Bittacus.* For years known only from the single specimen described below, despite efforts to obtain additional representatives, *Eremobittacus* is indeed solitary or alone. The habitat, when I visited it in 1969 and 1972, was semi-desert, along a dry stream bed bordered by sparse, thorny acacia-like trees and herbaceous plants 1–3 feet high shaded by these trees; the soil was dry, stony and mostly bare between the larger plants. (While the search for additional *Eremobittacus* was unsuccessful on both visits, a still undescribed species of *Bittacus* was found, in 1972, in the herbaceous vegetation.)

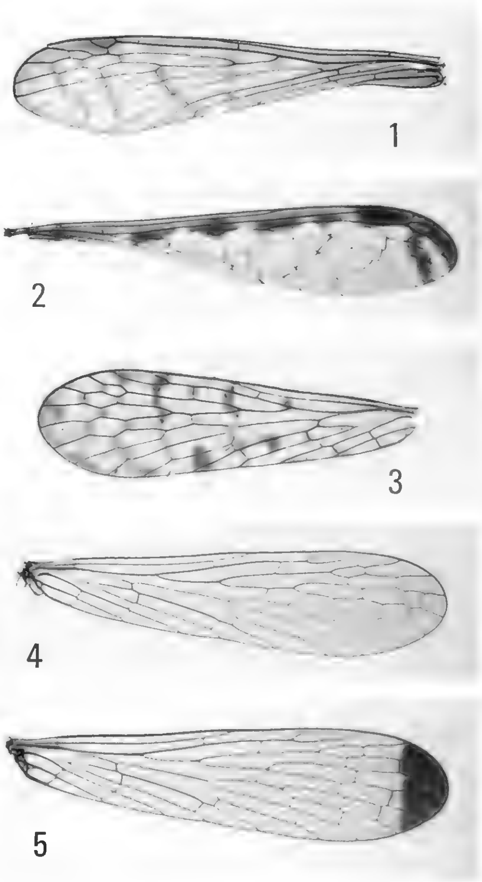
Eremobittacus spinulatus **Byers,** **New Species**

(Figs. 1, 6, 7–12)

Description.—Based on 1 ♂, pinned.

Head: Dorsal surface dark yellowish brown with extremely short, slender, yellowish hairs at each side above eyes, each hair arising from a microscopic, subconical cuticular spinule (cf. Fig. 7); broad median zone behind ocellar triangle without hairs (spinules only). Ocellar triangle dark brownish black with two black setae above median ocellus; lateral ocelli twice diameter of median ocellus. Rostrum dark yellowish brown, genae dark brown; mouthparts amber brown with curved, yellow setae on tips of maxillae. Antenna dark yellowish brown with short yellowish hairs; approximately 20 flagellomeres (separations indistinct beyond 12 or 13); length about 6 mm.

Thorax: Pronotum with three rounded, transverse ridges, unevenly dark yellowish brown, darkest laterally where ridges converge; anterior ridge with low prominence at each side of wide, shallow, median emargination, each prominence bearing stout, black setae (on holotype, 2 on left side, 3 on right). Mesonotum and metanotum sordid dark yellowish brown with numerous tiny spinules in broad median band, short yellowish hairs on each scutellum. Pleural surfaces, coxae and mera shiny black except brownish black on propleuron and close beneath wing attachments, spinulose, with sparse, pale setae. Three or four thick, black setae on outer surface of hind coxa; two smaller black setae on each epimeron.



Figs. 1–5. Wings of new species of Mecoptera. 1, Left fore wing of *Eremobittacus spinulatus,* male holotype. 2, Right fore wing of *Nannobittacus dactyliferus,* male paratype. 3, Left fore wing of *Panorpa sentosa,* male paratype. 4–5, Right fore wings of *Panorpa truncata,* male paratype (4) and female paratype (5).

Fore femur yellowish brown, not swollen, with abundant spinules and interrupted row of black setae on anterior (4 setae),

Fig. 6. *Eremobittacus spinulatus,* male holotype, left lateral aspect.

dorsal (3–4) and posterior (7) sides; middle femur resembling fore femur but with 9, 7 and 12 setae in uneven rows. Hind femur mostly black, dark yellowish brown near outer end, greatly swollen in basal two-thirds (Fig. 8), abundantly spinulose (Fig. 7), with some spinules bearing short, dark hairs; black setae on basal one-third, sparse (2–4) on anterior (outer) surface, sparse dorsally, more numerous (14–16) in irregular row on posterior surface. Tibiae yellowish brown with scattered black setae; spinules in encircling rows, few bearing short, pale hairs; tibial spurs long, slender. Basitarsus of fore leg subequal in length to second and third tarsomeres together, much longer than fourth; that of middle leg slightly longer than second and third together. Hind basitarsus approximately same length as long, thick fourth tarsomere, shorter than second and third together.

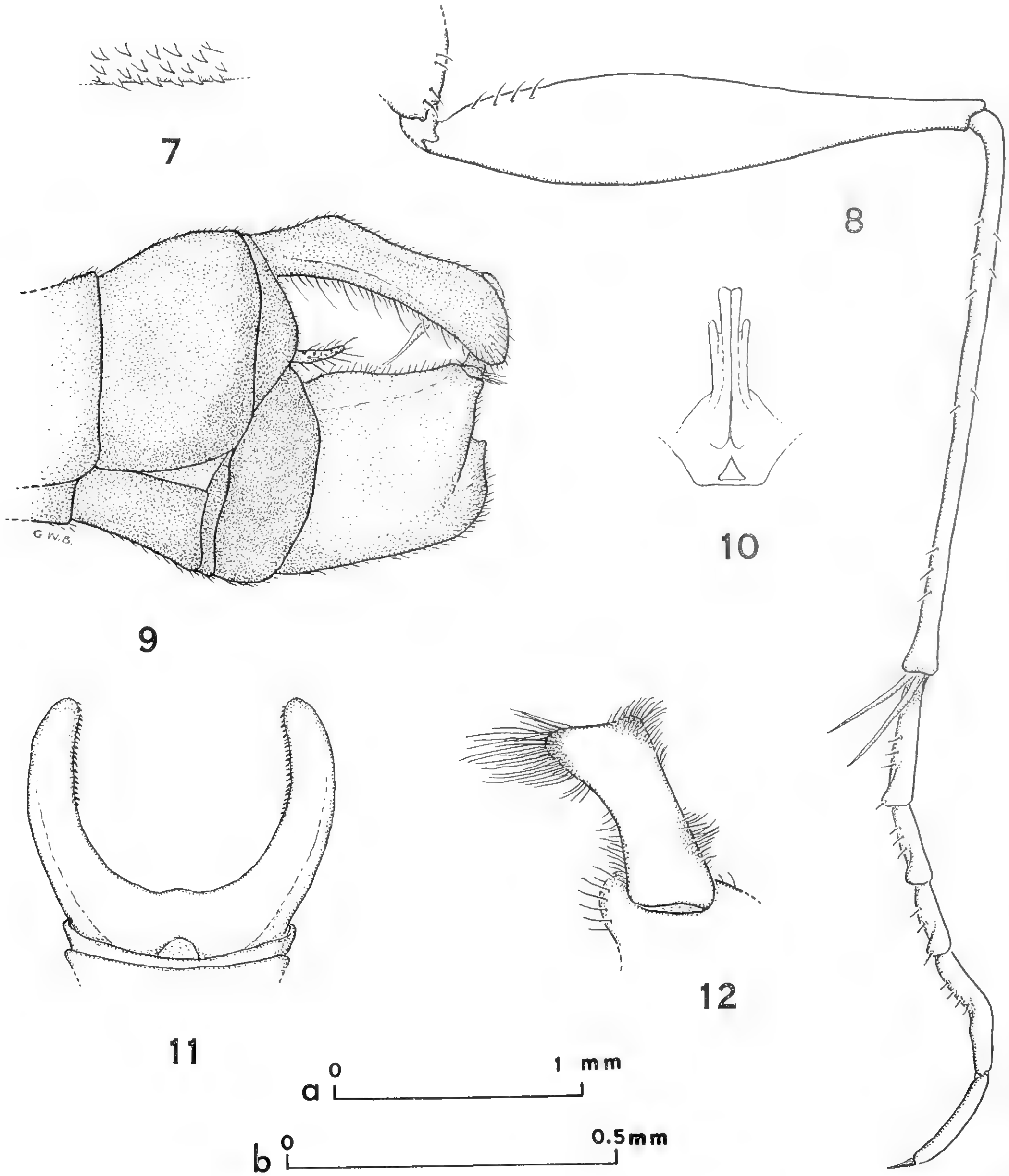
Wings (Fig. 1) faintly tinged with yellowish, stigma light brown; diffuse light yellowish brown clouding at ORs, FRs, in costal and subcostal cells, along all three ranks of cross-veins, at wing apex and in basal one-third of wing. Sc ending slightly beyond level of FRs; Scv opposite FRs. Cross-veins in radial and medial fields in approximate transverse-diagonal alignment.

Abdomen of male: Terga 2–6 mahogany-colored (dark reddish brown), unevenly darker along posterior and lateral margins, with abundant short hairs, each arising from slightly raised spinule. Corresponding sterna nearly black. Terga 7–8 unevenly blackish brown; sterna black. Epiandrial lobes widely divergent (Fig. 11), only about as long as basistyles, their dorsal and ventral margins thickened and approximately parallel, apex rounded (Fig. 9), lobes light brown, with numerous spinules on most of surface, some bearing short hairs; longer hairs along lower margin, near apex and on inner surface; small, black, recurved spines on inner surface at apex and along upper margin. Cerci short, narrowing toward tip. Basistyles light brown with numerous setae longest and darkest posteriorly below base of aedeagus and along dorsal margin (Fig. 9). Dististyles conspicuous (Fig. 12), with dark setae in groups along anterior and posterior margins. Aedeagus (Fig. 10) short, thick in basal two-thirds, abruptly more slender toward apex; base flanked by strongly sclerotized penunci.

Measurements: Body length approximately 13.8 mm.; length of fore wing 13.3 mm.

Type.—Holotype, ♂, and only specimen, collected near Petlalcingo, Puebla, Mexico, on 21 August 1963, by F. D. Parker and L. A. Stange. The label indicates three miles north of Petlalcingo, but only a trail goes north from the town, into mostly desert habitat. The actual locality (later confirmed by Lionel Stange) is at a bridge on Highway 190, three miles northwest of the junction of this highway and a side road into Petlalcingo. The type was presented to the Snow Entomological Collection, Natural History Museum, University of Kansas, by Dr. Frank Parker.

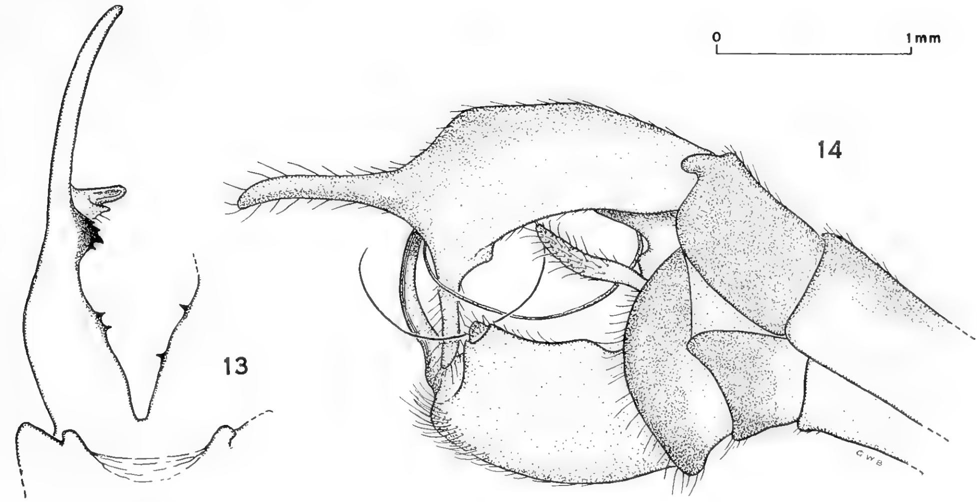
Discussion.—Chance discovery of a species (or individual) so different that it justifies placement in a separate genus is not without precedent in the Mecoptera. But in such cases, subsequent searches at or near the type locality have usually yielded additional specimens (e.g., *Orobittacus obscurus* Villegas and Byers, in central California). In the case of *Eremobittacus spinula-*



Figs. 7–12. *Eremobittacus spinulatus,* male holotype. 7, Detail of spinules on femur; note apical hairs at upper right and lower left. 8, Left hind leg, left lateral aspect. 9, Terminal abdominal segments, left lateral aspect. 10, Base of aedeagus, posterior aspect. 11, Epiandrial lobes, dorsal aspect. 12, Right dististyle, dorsal aspect. Scales: a—figs. 8–11; b—fig. 12.

tus, however, repeated collections made at the type locality and in the apparently correct season by myself and others have not rediscovered this species.

The reasons for placing this unusual bittacid in a genus separate from *Bittacus* have been discussed above. The specific name refers to the microscopic spinules on most of the body surface, a characteristic unique to this species.



Figs. 13–14. *Nannobittacus dactyliferus,* male paratype. 13, Right epiandrial lobe (and part of left), dorsal aspect. 14, Terminal abdominal segments, right lateral aspect. Scale: both figures.

Nannobittacus dactyliferus Byers, New Species
(Figs. 2, 13–14)

Description.—Based on 2 ♂, pinned.

Head: Occiput yellowish brown, vertex and frons above antennal bases black, granular; ocellar prominence black; lateral ocelli more than three times diameter of median ocellus; frons below antennal bases brown medially, paler next to eyes; clypeus glossy yellowish brown, labrum darker brown at sides; maxillary palp brown except apical segment paler; mandible and maxilla yellowish brown. Eyes large, protuberant, converging slightly below antennal bases. Antenna yellowish brown, with approximately 18 flagellomeres (indistinct beyond ninth); antennal length about 5.1 mm.

Thorax: Pronotum dark brown, with three transverse, rounded ridges; thick anterior ridge slightly upturned with low prominence at each side bearing one long, slender, hair-like seta, also shorter setae; short setae on middle and posterior ridges. Mesonotum glossy blackish brown with sparse, fine pale setae; metanotum only about half as long as mesonotum, blackish brown, glossy except D-shaped median area below mesoscutellum. Pleural surfaces, coxae and mera unevenly brownish gray, finely pubescent, with sparse yellowish setae longest and most dense on anterior coxae. Femora light grayish brown, darkened at apex; three or four black setae on outer surface. Tibiae and tarsi dark yellowish brown, setae black, tibial spurs nearly black but with short, yellowish hairs.

Wings (Fig. 2) lightly tinged with yellowish brown, veins brown, with undulating dark brown markings along costal border to wing apex, with subapical branch across outer cross-veins and reaching wing margin in outer cell M_1; five small, brownish transverse clouds in cell M between OM and FM. In fore wing, Scv opposite ORs, Sc joins C opposite FRs; one Pcv; 1A ending slightly beyond level of h; narrow, brownish borders around nygmata.

Abdomen of male: Terga 2–7 sordid dark yellowish brown anteriorly, dark brown posteriorly; corresponding sterna narrow, sordid yellowish brown except sternum 7 lighter yellowish brown and abruptly widened posteriorly. Tergum 8 brown throughout, with low, rounded dorsolateral lobe at each side; sternum 8 light brown. Epiandrial appendages (Fig. 14) brown along dorsal and apical margins, including slender, terminal (posterior) prolongation which curves slightly mesad, pale brown ventrally and pale yellowish brown on slender ventral prolongation; slight protuberance on dorsal margin near mid-length, directed mesad, another, rounded and flattened, near base of ventral prolongation. Black spines on dorsal protuberance and on inner dorsal margin of epiandrial appendages (Fig. 13). Basistyles only about half as long as epiandrial appendages, brown dorsally grading into light brown ventrally and posteriorly. Dististyles inconspicuous, short, thick, rounded, strongly turned inward and forward. Cerci nearly as long as dorsal edge of basistyle, sharply pointed at apex, brown except pale near attachment to proctiger. Aedeagus long, coiled, unmodified near base, becoming filiform at approximately level of lower edge of epiandrial appendage.

Measurements: Body length 17.0–18.8 mm. (holotype 17.0 mm); length of fore wing 17.2–18.0 mm. (holotype 17.2 mm.).

Types.—Holotype, ♂, collected in Malaise trap, in Sucumbios, Ecuador (0.5°S, 76.5°W), elev. 270 m., 12–22 February 1995, by Peter Hibbs; specimen received by way of Dr. J. S. Ashe. Paratype ♂, in Malaise trap, Limoncocha, east of Coca, Napo Province, Ecuador, 22 May 1976, by David G. Young; received from Dr. C. P. Alexander, who had found it among Ecuadorian crane flies sent to him. Habitat for both these specimens is described as wet, lowland tropical forest (secondary forest in the case of the paratype).

Discussion.—In most characters, *Nannobittacus dactyliferus* is not strikingly different from other known species in its genus, but the epiandrial appendages (tergum 9) are conspicuously different from those in any other species. *Nannobittacus pollex* Byers and Roggero has a small, thumb-like projection from the lower margin of each epiandrial appendage, but this projection is less than one-fourth the length of those in *dactyliferus*. The name *dactyliferus* is derived from the long, slender prolongations of the epiandrial appendages (Latin *dactylus*, from Greek *dactylos* = finger; *fero* = to bear, carry). The possible function of the long, finger-like prolongations, the one at about a right angle to the other, is problematical.

Panorpa sentosa Byers, New Species
(Figs. 3, 15–19)

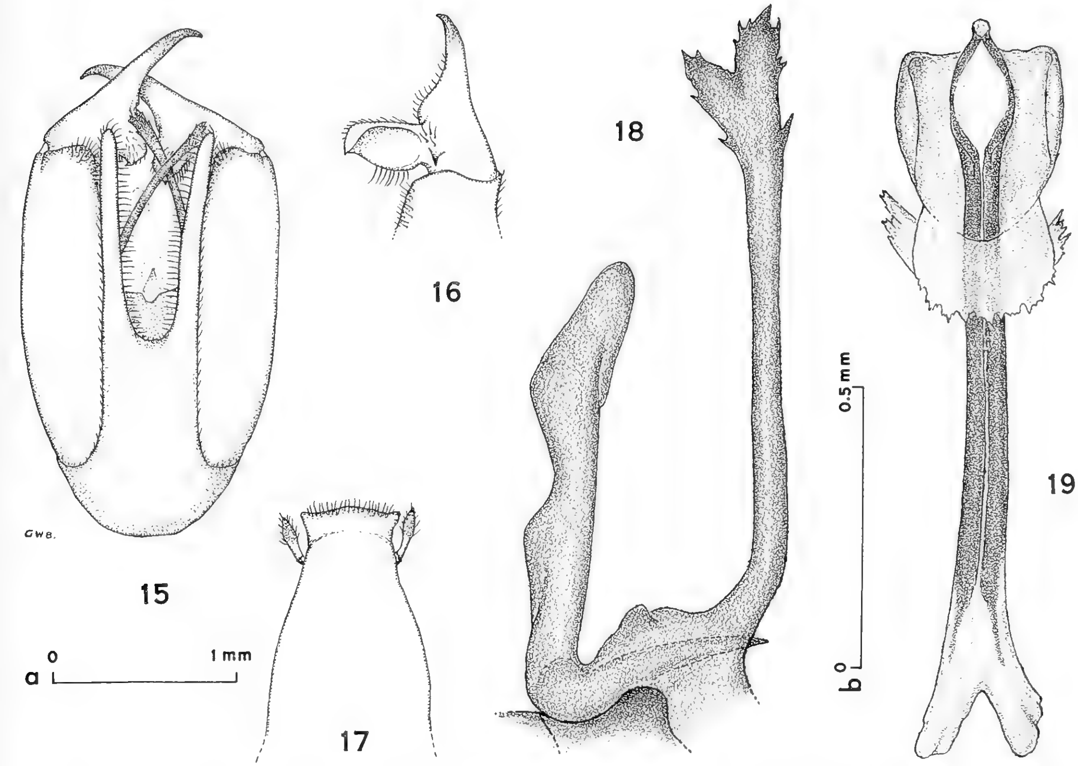
Description.—Based on 22 ♂ and 27 ♀, pinned, and 1 ♂, 2 ♀ in alcohol.

Head: Dorsum mostly shiny dark yellowish brown, slightly darker (or usually a brown spot) at each side of occiput adjacent to eye; ocellar prominence black, lateral ocelli about 1.5 times width of median ocellus. Rostrum yellowish brown, maxillary palps darker, dark brown on apical half of terminal segment. Antennal scape yellowish brown, pedicel brown, flagellum brownish black to black, with 32–36 flagellomeres in male (holotype 32 and 33), 33–36 in female (allotype 36). Antennal length, male, about 9.0 mm., female about 7.8–8.0 mm.

Thorax: Pronotum shiny dark brown except yellowish brown along mid-line and widening toward rear; 5–6 black setae along anterior margin on each side. Mesonotum and metanotum with broad, pale yellowish brown median stripe, brown at sides, nearly black just anterior to bases of fore wings; setae numerous, short, dark. Pleural surfaces, coxae and mera unevenly yellowish brown with scattered setae longest and most numerous on anterior surfaces of coxae. Femora, tibiae and tarsi yellowish brown, tibial setae black, fifth tarsomere dark brown.

Wings (Fig. 3) lightly tinged with yellowish brown; spots light brown, no complete bands; spots at ORs, FRs, from proximal end of stigma to fork of R_{4+5} or to M_1, outer end of stigma across fork of R_{2+3} to R_4, in cell 1st R_1, second cell M_3, cell M_4 and second cell Cu_1, in outermost radial and medial cells at wing margin, and along outer cross-veins, but variable.

Abdomen of male: Terga 2–5 light yellowish brown with short, pale setae; sterna



Figs. 15–19. *Panorpa sentosa*, paratypes. 15, Genital bulb of male, ventral (posterior) aspect. 16, Left diststyle, male, mesal aspect. 17, Ninth abdominal tergum, male, dorsal aspect. 18, Aedeagus and parameres, male, left lateral aspect. 19, Genital plates of female, ventral aspect (posterior end at top). Scales: a—figs. 15–17; b—figs. 18–19.

2–5 slightly paler. Segments 6–9 yellowish brown. Notal organ comprising broadly rounded, mid-caudal margin of tergum 3 with short, downcurved yellow setae, and sharp, strongly sclerotized peg on anterior tergum 4. Posterodorsal surface of segment 6 glabrous and slightly depressed (genital bulb "closes" against this area). Segments 7 and 8 short, 1.5–2 times as long as their diameter. Tergum 9 (Fig. 17) expanded at apex, lateral corners acute, caudal margin slightly rounded, nearly truncate; cerci distinctly two-segmented. Sternum 9 (Fig. 15) prolonged to nearly half length of basistyles, then separated into slender hypovalves that extend slightly beyond basistyles. Outer margin of each diststyle slightly concave, apex moderately curved, strongly sclerotized; basal cup greatly prolonged ventrad (Fig. 16), its blunt apical margin with single small tooth in most individuals; blackened, acute spine near base. Aedeagus (Fig. 18) with undivided ventral and dorsal parameres, dorsal ones compressed, somewhat spatulate, rounded at apex. Ventral parameres well sclerotized, rod-like through most of their length, extending beyond ends of basistyles and projecting ventrad between hypovalves, each deflected slightly laterad near base; apex variable, generally of two short, flat, expanded arms with spinose margins, often with a few setae. Ventral and dorsal valves small, concealed between bases of parameres in lateral aspect.

Abdomen of female: Terga shiny yellowish brown to light brown; sterna 2–5 slightly paler than corresponding terga; setae pale; cerci black. Subgenital plate broadly rounded posteriorly, with small median point in some individuals, slightly rounded at sides, keeled along ventral midline. Posterior margin of apical genital plate (Fig. 19) nearly transverse, lateral edges curved ventrad; basal plate indistinct, only weakly sclerotized; axial portion greatly elongated, densely sclerotized through most of its length, anterior apodemes short, pale.

Measurements: Body length, male, about 7.1–9.2 mm. (holotype 8.8 mm.); female about 7.3–9.2 mm. (allotype 9.2 mm.). Length of fore wing, male, 8.7–11.1 mm. (holotype 10.4 mm.); female, 10.3–11.2 mm. (allotype 10.5 mm.).

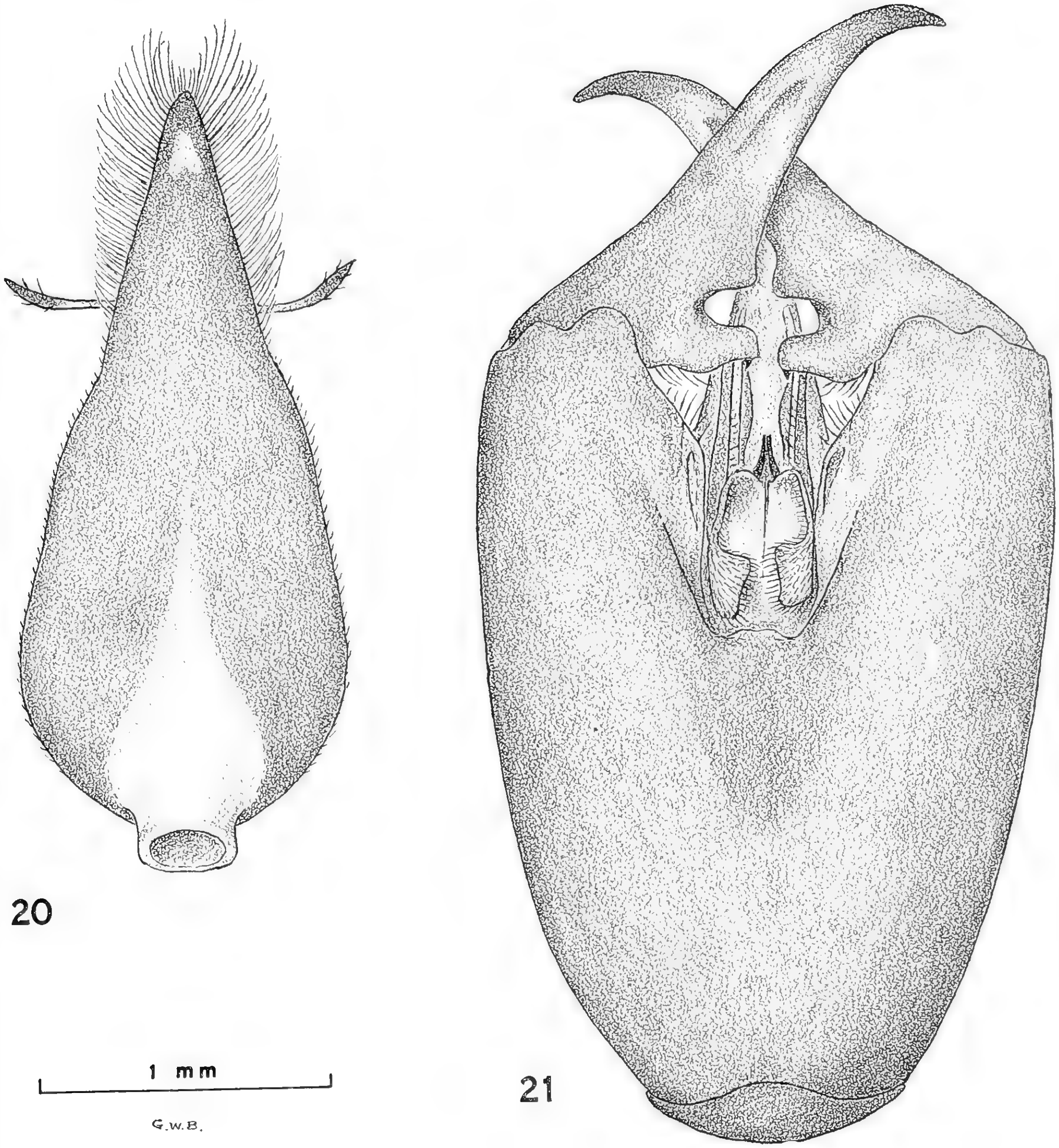
Types.—Holotype, ♂, allotype, two ♂ and three ♀ paratypes collected 14.9 mi. (24 km.) west of El Naranjo, San Luis Potosí, Mexico, on 26 August 1972, by G. W. Byers (field catalogue San Luis Potosí No. 15) and A. R. Thornhill. Additional paratypes, from San Luis Potosí: 14 mi. west of El Naranjo, 21 June 1971, N. D. Penny (3 ♂, 5 ♀); 15 mi. west of El Naranjo, 5 July 1971, N. D. Penny (7 ♂, 6 ♀); Hwy. 70, km. 82, along road to microwave tower Microondas Tortugas, 20 July 1988, C. L. Smith (3 ♂, 4 ♀); 16 mi. west of El Naranjo, 3500 ft., 8 September 1992, Wes Bicha (4 ♂, 1 ♀) and 9 Sept. 1992 (2 ♂, 7 ♀); from Tamaulipas, Rancho del Cielo, 3800 ft., 8 mi. west of Gomez Farias, 24–29 July 1971, G. E. and K. E. Ball (3 ♂, 4 ♀). Specimens collected by C. L. Smith are from the collection of the University of Georgia, Athens; those collected by Wes Bicha are in his collection.

Discussion.—Habitat at the type locality was forest of various oaks and a few other kinds of trees, beside Highway 80, 14.9 miles by road west of El Naranjo (1.6 miles below summit of pass and about 31 miles, or 49.5 km., by road west of Antiguo Morelos). Branches of all large trees bore numerous epiphytic bromeliads, mosses and liverworts; the undergrowth included woody shrubs up to two meters in height and herbaceous plants a meter or less high. Elevation 4000 feet (1220 m.); temperature 68°F; weather 100% cloudy, with rain ending collecting at 10:40 a.m. This is one of a very few localities in Mexico where *Panorpa* has been found lower than 5000 feet (1524 m.), perhaps because this is one of the northernmost places in Mexico where the genus has been found.

Norman D. Penny discovered the species, and information about its occurrence was passed to Byers and from him to Wes Bicha. Cecil Smith's finding it was an independent event.

The shape of sternum 9 and its hypovalves and the projecting ventral parameres with spinose apices make males of *Panorpa sentosa* readily recognizable. It is the terminal structure of the ventral parameres that gives the species its name (Latin *sentosa* = thorny). The unique tergum 9 is often not easily seen in pinned specimens; three other Mexican species of *Panorpa,* in the *involuta* group (Byers 1996), have the ninth tergum with approximately transverse posterior margin. In size and wing maculation *P. sentosa* somewhat resembles *P. mucronata* Byers, known only from Hidalgo, but the characters mentioned will easily differentiate males of these species. Females also can be readily recognized by the shape of the subgenital plate, which is short, broad, ventrally keeled and with a broadly rounded posterior margin in *sentosa* but unusually long and narrowly rounded posteriorly in *mucronata.*

Panorpa sentosa is a puzzling species because of the male's long ventral parameres that project conspicuously from within the genital bulb and have a complicated apex with numerous thorn-like points on the margin. In males of all other Mexican species, the ventral parameres have a simple apical margin that may be pointed or blunt but not irregularly jagged. Also, except in *P. sentosa,* the ventral parameres are shorter than the dorsal parameres, or in those species with two-branched ventral parameres the ventral branch is conspicuously shorter than either the dorsal branch or the dorsal parameres. When the ventral parameres project from the genital bulb, only their apices can be seen in lateral as-



Figs. 20–21. *Panorpa truncata*, male, paratype. 20, Ninth abdominal tergum, dorsal aspect. 21, Genital bulb, ventral (posterior) aspect, showing truncated ninth sternum. Scale: both figures.

pect, in other species, as contrasted to half their length projecting ventrad in *P. sentosa.*

Panorpa truncata **Byers, New Species**
(Figs. 4, 5, 20–26)

Description.—Based on 36 ♂, 39 ♀ pinned, and 3 ♂, 4 ♀ preserved in alcohol.

Head: Occiput, vertex and frons including ocellar prominence shiny black with sparse, very short, pale hairs on much of surface; clypeus shiny dark yellowish brown, labrum unevenly brown; maxillary palps yellowish brown, mandibles and maxillae brown. Scape and pedicel dark brown; flagellum mahogany brown basally, grading into black; 42–45 flagellomeres in male (holotype 44), 41–44 in female. Antennal length about 11–13 mm. in male, 11–12 mm. in female.

Thorax: Pronotum mostly black, dull yellowish brown medially on posterior transverse ridge, with very short, pale hairs; anterior margin turned upward, with 6–8 black setae and several shorter black hairs at each side. Mesonotum black at sides, light brown medially including scutellum; metanotum black at sides, more broadly light brown medially than mesonotum. Pleural surfaces, coxae and mera black with fine, short, whitish pubescence and sparse yellowish setae most dense on coxae and lower parts of mera. Fore and middle legs orange-brown on femora and tibiae, tarsi darker, fifth tarsomere black. Femur of hind leg dark orange-brown, tibia sordid yellowish brown, tarsus brown, darkening toward apex.

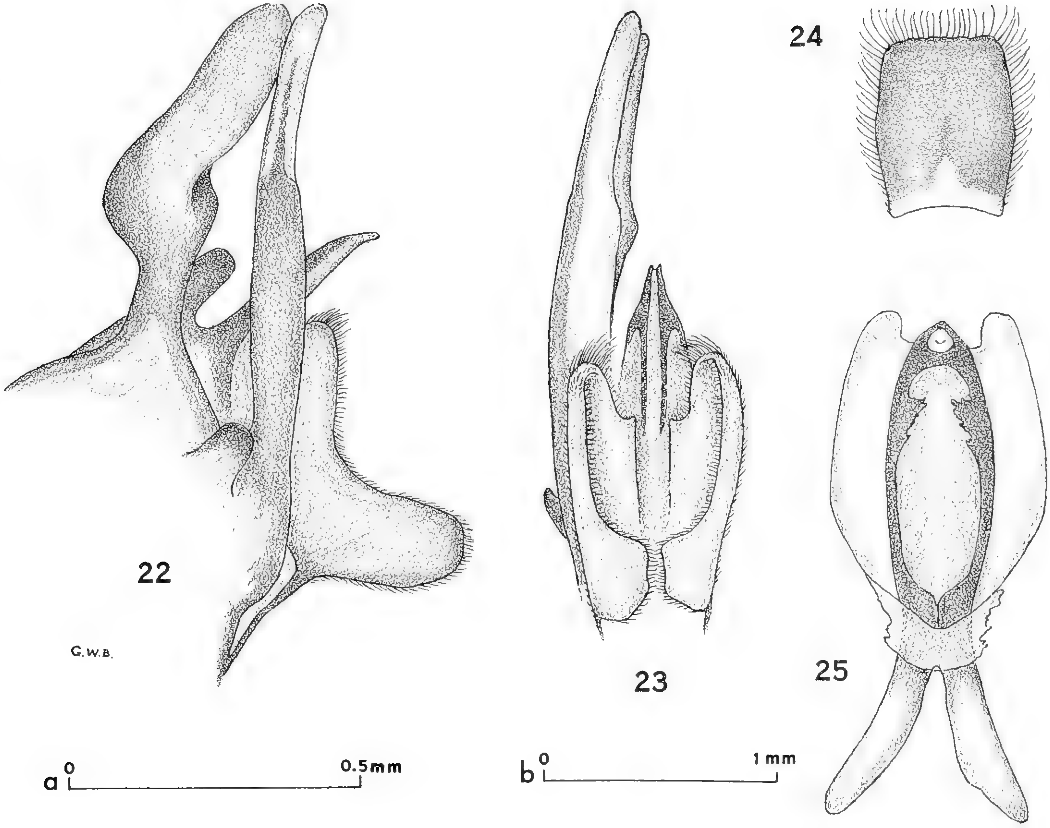
Wings tinged with yellowish brown, unmarked except for slightly darkened stigma, in male (Fig. 4), with dark brown apical band, from near end of R_2 to end of M_2 and to wing apex, and slightly darkened stigma, in female (Fig. 5). Veins R_2 and R_3 unbranched. Whitish thyridium at FM.

Abdomen of male: Segments 2–8 ferrugineous with short, pale yellowish hairs sparse on terga, more dense on sterna; hairs longer on sixth segment. Segments 7 and 8 each about as long as 6, much longer than more anterior segments. Notal organ a broad, truncate median lobe on hind margin of tergum 3, with downcurved yellowish hairs, and a low, blunt median process on tergum 4 with yellowish hairs directed cephalad. Segment 9 shiny black to brownish black except ferrugineous on petiole inserted into segment 8; setae brown to black. Ninth tergum (Fig. 20) elongate, narrowing posteriorly to acute apex, with long, black hairs along sides beyond slender, apparently single-segmented cerci; ferrugineous spot near apex. No hypovalves or other prolongations on ninth sternum (Fig. 21). Basistyles fused for more than half their length. Dististyles (Fig. 21) black basally, dark orange-brown in apical half; basal cup usually with blackened tooth on inner, dorsal margin. Aedeagus (Figs. 22, 23) with two-branched vental parameres; ventral branch only weakly sclerotized, covered laterally with short hairs, its ventral prolongation curved slightly mesad; dorsal branch rodlike, darkly sclerotized at base, pale at apex. Dorsal parameres compressed, wide in lateral aspect, rounded at apex. Ventral valves acutely tipped, more darkly sclerotized along dorsal (upper) curvature than on lower side. Dorsal valves small, densely sclerotized, apically rounded.

Abdomen of female: Terga 2–5 unevenly dark ferrugineous to dark brown (probably some post-mortem effects involved), with short, pale setae; terga 6–8 orange-brown, 9 dark brown, 10 brown on posterior half, with long, black setae; cerci black. Sterna 2–5 yellowish orange to light ferrugineous, wide, with pale setae; 6–8 ferrugineous. Conspicuous laterotergites, attenuate anteriorly, rounded posteriorly, on segments 7 and 8. Subgenital plate (Fig. 24) broad with transverse or very broadly rounded caudal margin and long bordering hairs; mostly dark brown but abruptly paler at base. Genital plates (Fig. 25) with divergent anterior apodemes; apical plate white, only weakly sclerotized; extent of basal plate not evident.

Measurements: Body length, male, about 20.6–22.4 mm. (holotype 22.4 mm.); female, about 14.7–15.4 mm. (allotype 14.9 mm.). Length of fore wing, male, 16.6–17.4 mm. (holotype 17.4 mm.); female, 16.3–17.1 mm. (allotype 16.3 mm.).

Types.—Holotype, ♂, allotype and 19 ♂, 23 ♀ paratypes collected near Highway 110, 5.4 km. by road north of Mazamitlá (measured from major road junction at north edge of the town), Jalisco, Mexico, 10 July 1985, at elevation 6890 feet (2120 m.), by George W. Byers (field catalogue Jalisco no. 5). One ♂, two ♀ paratypes from nearly same locality (a few hundred meters farther north), collected by David K. Faulkner, 12 July 1982, in the Natural History Museum, San Diego, California; 18 ♂ and 17 ♀ paratypes collected 3.6 mi. (5.8



Figs. 22–25. *Panorpa truncata*, paratypes. 22, Aedeagus and parameres, male, left lateral aspect. 23, Aedeagus, ventral aspect. 24, Subgenital plate of female, ventral aspect (posterior end at top). 25, Genital plates of female, ventral aspect (posterior end at top). Scales: a—figs. 22–23, 25; b—fig. 24.

km.) south of Mazamitlá, 26 and 29 August 1989, by Wes Bicha, in his collection.

The type locality, about 30 km. south of Laguna de Chapala, is a small valley in sparse oak woods (trees 10 to 13 m. high), with shrubs 1–2 m. high, lower herbaceous plants and grasses; slope of valley floor about 15–20 degrees.

Discussion.—This species was discovered by Dr. David K. Faulkner of the Natural History Museum, San Diego. In 1984, he sent me one male and two females for identification. The first thing one notices about *Panorpa truncata,* apart from its large size, contrasting coloration (Fig. 26), and the sexual difference in wing coloration, is that there is no prolongation of the male's ninth sternum, which in other species is usually divided into separate hypovalves. Males of every other species of Panorpidae in the world possess this structure. It has proved to be useful in taxonomy because it varies in shape from species to species but is fairly constant within a species. Describing Faulkner's obviously new species based upon what appeared to be a monstrosity seemed unwise. Accordingly, I made a brief trip to Jalisco the next summer (1985) to find additional males. And all of them lacked hypovalves. The species takes its name from the absence of these sternal prolongations (Latin *truncata* = cut off, or deformed, mutilated). I have never determined the function of hypovalves in male panorpids but assume they are tactile; clearly *P. truncata* has no need of them.

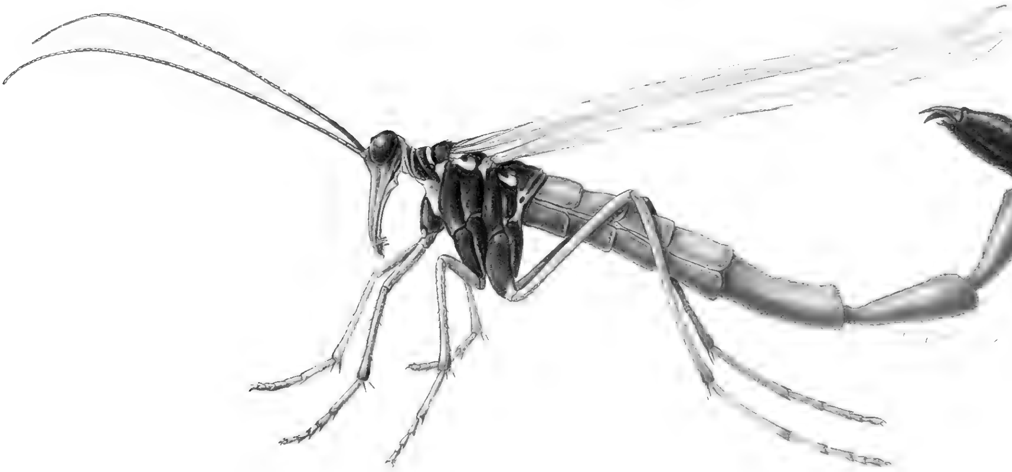


Fig. 26. Male *Panorpa truncata*, left lateral aspect. Drawing by Anne Musser.

Males of *P. truncata,* when inactive, hold their wings roof-like above the body and the tip of the abdomen curved forward so as to be virtually concealed by the wings. Females, more active than males, hold their black-tipped wings more out to the sides. Both males and females were often (usually, if undisturbed) seen resting in a vertical position, such as clutching a plant stem or tall grass blade. When alarmed, females flew higher than males into low shrubs and herbaceous vegetation.

At the time of these observations, two males of a second (still unnamed) species, somewhat smaller than *P. truncata* and with orange body including orange genital bulb, were collected. These had well-developed hypovalves.

ACKNOWLEDGMENTS

I am indebted to David Faulkner, Norman Penny, Frank Parker, and Lionel Stange for discovering three of the species described here, also to Wes Bicha for his tireless efforts to make the Mecoptera better known. My thanks to all these colleagues and to Steve Ashe and Cecil Smith for their awareness of my interest in Mecoptera and for forwarding specimens. The efforts and patience of Sharon Lee Hopkins and Cynthia Woods in putting the paper into computer and making corrections are much appreciated. Comments by two anonymous reviewers are similarly appreciated. This is contribution number 3188 from the Division of Entomology (Snow Entomological Collection), University of Kansas Natural History Museum, Lawrence, Kansas 66045, U.S.A.

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BIOLOGICAL NOTES ON *SPARASION* LATREILLE (HYMENOPTERA: SCELIONIDAE), AN EGG PARASITOID OF *ATLANTICUS GIBBOSUS* SCUDDER (ORTHOPTERA: TETTIGONIIDAE)

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Abstract.—The first behavioral observations for any species of *Sparasion* and the first report of the genus *Atlanticus* (Orthoptera: Tettigoniidae) as a host of *Sparasion* are presented. In Florida, a number of female wasps were observed burrowing headfirst into sandy areas. In every instance where a female burrowed into sand and the area subsequently was excavated, an egg of *Atlanticus,* oriented vertically, was found at 12 to 15 mm beneath the surface. Females emerged headfirst from the sand if they remained underground for more than a few minutes. A single female was excavated from the ground while in the process of ovipositing into an egg; she was at its uppermost end with her head oriented toward the surface.

Key Words: Hymenoptera, Scelionidae, *Sparasion,* Tettigoniidae, *Atlanticus gibbosus,* egg, parasitoid

The genus *Sparasion* Latreille is represented by over 100 species throughout the Holarctic and Oriental regions (Johnson 1992), eight of which occur in America north of Mexico (Muesebeck 1979). Essentially nothing is known about the biology or behavior of these wasps. Kozlov and Kononova (1990) recently described over 50 new species of *Sparasion,* and not a single one had been reared. The paucity of biological or behavioral data for species in this genus is doubly remarkable because it has been recognized for nearly 200 years (described in 1802), and its single known host in the Americas is the Mormon cricket, *Anabrus simplex* Haldeman, an insect of legendary stature in the United States. Surprisingly, even for this common, well-known host, no truly biological or behavioral observations have been published for its parasite, *Sparasion pilosum* Ashmead, except the host record itself (Cowan 1929) and subsequent citations of this record (Mills 1941, Hitchcock 1942, Wakeland 1959, Muesebeck 1979). Although a few additional papers refer to *Sparasion* in relation to a potential host, these were merely specimens of *Sparasion* collected in a habitat relative to the potential host. For example, Spencer (1958) reported *Sparasion* sp. "probably parasitic upon eggs of the tettigoniid *Anabrus longipes* Caudell," and Thorens (1991) collected *Sparasion* sp. in a locality containing an acridid grasshopper (*Chorthippus* sp.).

In this paper I present anecdotal observations made on the behavior of an undescribed species of *Sparasion* in Florida that attacks eggs of *Atlanticus gibbosus* Scudder (Orthoptera: Tettigoniidae). This is the first report of *Atlanticus* as a host for *Sparasion.* These observations were made in 1974 and

1975 and were to form the basis of more detailed studies to follow. Other obligations prevented further investigation, however, and as no one has published biological information for the genus in the intervening twenty years, my notes provide enough data to highlight significant aspects of the heretofore unknown behavior of a species of *Sparasion*.

METHODS

I made observations in two areas about 16 km apart in Alachua County, Florida. In both areas the soil consisted of sand, which in the absence of rain, was loose and powdery dry for the top 1 or 2 cm.

Alachua (0.5 km southeast). This site was a large, sandy, disturbed area formed by the intersection of a railroad track and several dirt roads. The entire area had been bulldozed through a low hillock in recent times, probably as a barrow pit. A number of annual and perennial plants, most notably *Cassia* sp. (Fabaceae), were returning to the site.

Gainesville (grounds of the Florida State Collection of Arthropods, Division of Plant Industry building). This site was an unpaved road that had been cut through the woods around the back side of the DPI building. The site has been paved in the intervening years since observations were first made.

Determination of the status of this *Sparasion* as undescribed was made first by the late C. F. W. Muesebeck and subsequently was confirmed by Lubomir Masner, Agriculture Canada. Additionally, I have compared the species with types and other specimens in the National Museum of Natural History, Smithsonian Institution, and it appears to differ from all available material. Currently no systematist in authority is willing to describe the taxon. All voucher specimens collected in this study are housed in the Florida State Collection of Arthropods, Gainesville, Florida, along with large series of material representing the same taxon.

Field recognition of this species requires experience based upon preserved specimens. The wasps are ca. 5 mm in length, appear black in color, and are most easily seen as they fly or walk back and forth over a small area of soil. Females are distinguished from males by the orange legs (black in males) and short, hidden antennae (elongate and easily seen in males).

Determination of *Atlanticus gibbosus* was made by D. A. Nickle, who compared dried eggs excavated from the Alachua site (21 July 1975) with eggs dissected from dried adult female *Atlanticus* in the collection of the National Museum of Natural History. *Atlanticus gibbosus* is the only common shield-backed grasshopper found in Florida and is particularly abundant during the summer months when my observations were made.

OBSERVATIONS

Alachua, 21 to 27 July 1974.—On 21 July I arrived at the site at 10:45 am and saw several female *Sparasion* flying slowly over a small sandy area at about 2 to 5 cm above the surface. Two to 5 wasps were seen walking or flying in any given area (approximately 30 cm^2 to 1 m^2). Once a female landed on the ground she walked about erratically over the surface with her abdomen bobbing slightly up and down, wings folded and held horizontally over the abdomen. The antennae were extended downward in an inverted V-shaped pattern just above the surface. When a female found an area of interest, she touched her antennae on the sand and vibrated them; then she would plunge headfirst into the sand. As she entered, she rotated her body from side to side, and her antennae appeared to play some role in excavation, but this could not be confirmed. In most cases her body would quickly disappear beneath the surface, and just as quickly she would back out completely and begin the probing activity in nearby areas. Females did not come out headfirst unless they had been underground at least several minutes.

In one instance I saw a female emerging headfirst from the sand. I excavated at the point of emergence and found a tettigoniid egg ca. 6 mm in length at 13 mm below the surface (top of egg at 13 mm). A few minutes later I saw a female wasp burrow headfirst into the sand. It took 40 to 50 seconds for her to completely disappear from sight. Five minutes later she emerged headfirst from the soil. Then almost immediately another female burrowed headfirst into the sand in the same area. After 8 minutes I excavated the soil and found the female near an egg. The top of this egg was 10 mm beneath the surface. The egg was 6 mm in length. Shortly thereafter I saw another female burrow headfirst into the ground and completely disappear in ca. 45 seconds. After waiting 17 minutes for her to emerge, I excavated the sand and found an egg. The female wasp was oriented head upwards, above the tip of the egg, with her ovipositor embedded into it. When I removed the egg, the wasp was still attached to it, but she broke free and flew away. This egg was 12 mm below the surface and was 6 mm long. I placed the above eggs in gelatin capsules, but nothing emerged from them.

On 23 July I visited the same site from 9:30 to 11:30 am and saw numerous males flying above the sand; some alighted on the ground, others alighted on *Cassia.* I did not see any females until 10:15 and observed no digging or mating attempts.

On 25 July I visited the site at 10:30 am. The sand was slightly damp on the surface. I saw males and females cruising the area. In one case I saw 7 females on the ground within a 30 cm^2 area. Some began to burrow into the sand but then stopped. No females entered the ground. Some of the females approached each other, and occasionally one would "hop" at the other (a short jump of 1 to 2 cm). Several times I saw females digging within 5 mm of each other. It began to rain heavily, and the wasps disappeared.

On 27 July I arrived at 11:00 am. A few males were flying over the sand and landing on *Cassia.* The area was extremely wet, and no females were seen. It rained heavily for the next few days as well, and I abandoned the site.

Gainesville, 2 July 1975.—At 10:45 am, along the edge of a sandy road, I observed a female burrow headfirst into nearly level, loose, dry sand. In 10 minutes a female (presumed to be the same, but perhaps incorrectly, see below) emerged headfirst from the sand about 3 mm from where she entered. Her body was covered with dust, and she spent several minutes cleaning her abdomen and then her head. Then she walked away. I immediately excavated the sand beginning about 10 cm away from the emergence site. I excavated to a depth of 20 mm (the first 15 mm were dry, then became damp). At 15 mm in depth and near where the female emerged, I found two eggs of a tettigoniid a few cm apart. These were about 5 mm in length and placed vertically in the moist sand with the tops at the 15 mm level. I also found three female *Sparasion,* heads upright, near these two eggs but not in contact with them. These females either walked or flew away quickly as the sand fell away from their bodies during my excavation. I brought the eggs into the lab and placed them in gelatin capsules, but nothing emerged.

DISCUSSION

During eight days of observations (over a two year period), the number of both male and female wasps seen flying and landing on the sand varied, with up to seven females in a 30 cm^2 area. The absence of observed matings was unusual for such an abundance of individuals, but matings may have taken place earlier or later than the period during which my observations were made (in late morning, ca. 9:30 to 11:30 am).

Females seemed most attracted to areas of dry, friable sand; wet sand appeared to pose a deterrent to initial surface penetration. All observed females entered the sand headfirst. After a female entered the sand her presence was undetectable from the surface until she either backed out (usually only a few seconds after penetration) or emerged headfirst. It appeared that once a female found a spot beneath the surface that was of interest, presumably because a tettigoniid egg was present, she managed to reverse direction under the sand. Females apparently could detect host eggs from the surface, but they either could not detect other wasp females or these females were not a deterrent.

Although I could not demonstrate by evidence of successful rearing that *Atlanticus gibbosus* is, in fact, a true host of this *Sparasion,* I believe that the observations point to this conclusion. The constant association of female wasps with *Atlanticus* eggs and the presence of a female wasp ovipositing into an egg both suggest that this tettigoniid is likely to be a host. Additionally, *Atlanticus* is a member of the Tettigoniinae, as is the only proven host of *Sparasion* in the Nearctic, the Mormon cricket.

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A REVISION OF NEOTROPICAL *DITRICHOPHORA* CRESSON (DIPTERA: EPHYDRIDAE)

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Abstract.—Neotropical species of *Ditrichophora* Cresson are reported for the first time from that region and are revised. Two new species are described and illustrated: ***D. bella*** (Dominican Republic. Monseñor Nouel: near Jima (19°01.2′N, 70°28.8′W; 670 m) and ***D. chiapas*** (Mexico. Chiapas: El Triunfo (49 km S Jaltenango)). A diagnosis of the tribe Discocerinini and an annotated key to New World genera are also provided.

Key Words: Diptera, Ephydridae, shore flies, *Ditrichophora,* New World tropics

Recent field work on the Dominican Republic and Jamaica resulted in the discovery of an undescribed species of *Ditrichophora* Cresson, a genus that has not been reported from the neotropics (Wirth 1968, Mathis and Zatwarnicki 1995). The purpose of this paper is to describe this species, which is apparently widespread in Central America and on islands of the West Indies, and a second Neotropical species that was recently found in southern Mexico. I am describing both species within the context of a revision, including an annotated key to the New World genera of Discocerinini and a revised description of the tribe and genus.

Ditrichophora was described in 1924 (Cresson 1924:159) for "Discocerine species having only two facial bristles. . ." and that are ". . . shining and in many respects resemble those of the Psilopini." The genus has remained in the tribe Discocerinini (subfamily Gymnomyzinae) since then even though the tribe has been recharacterized and now includes only those genera that are closely related to *Discocerina* Macquart (Mathis and Zuyin 1989, Mathis and Zatwarnicki 1995). Other genera that had been included in the tribe, such as *Paratissa* Coquillett and *Rhysophora* Cresson, are now in the tribe Discomyzini (subfamily Discomyzinae).

Within Discocerinini, *Ditrichophora* is closely related and very similar to *Gymnoclasiopa* Hendel. Both genera represent basal lineages with *Gymnoclasiopa* being the sister lineage to the remaining genera of the tribe (Zatwarnicki, personal communication). For many decades, *Gymnoclasiopa* was treated as a subgenus within *Ditrichophora* (Cresson 1942, Wirth 1965). Only recently (Zatwarnicki 1992 and personal communication), with evidence that *Gymnoclasiopa* is the most basal lineage in the tribe, was it recognized as a distinct genus from *Ditrichophora.* In this paper, the concept and characterization of *Ditrichophora* excludes *Gymnoclasiopa,* and the latter is considered a distinct genus in the key to genera.

Species of *Ditrichophora* occur throughout the Old World, but until the discovery of the two species being described here, the genus was known only from the Nearctic Region in the New World. Worldwide, there are approximately 39 species (Mathis and Zatwarnicki 1995). Most species occur in temperate, freshwater environments, especially in the northern hemisphere.

METHODS

The terminology and methods used in this study were explained previously (Mathis 1990). Because of the small size of specimens, study and illustration of the male terminalia required the use of a compound microscope. To better assure effective communication about structures of the male terminalia, I have adopted the terminology of other workers in Ephydridae (see references in Mathis 1986). Usage of these terms, however, should not be taken as an endorsement of them from a theoretical or morphological view over alternatives that have been proposed (Griffiths 1972, McAlpine 1981). Rather, I am deferring to tradition until the morphological issues are better resolved.

Three ratios (one cephalic, two venational) are used commonly in the descriptions and are defined here for the convenience of the user (ratios are ranges based on three specimens).

1. Gena-to-eye ratio is the genal height measured at the maximum eye height divided by the eye height.
2. Costal vein ratio: the straight line distance between the apices of veins R_{2+3} and R_{4+5}/distance between the apices of veins R_1 and R_{2+3}.
3. M vein ratio: the straight line distance along M between crossveins dm-cu and r-m/distance apicad of crossvein dm-cu.

The specimens used in this study are primarily in the National Museum of Natural History (USNM), Smithsonian Institution. Paratypes of the Mexican species will be deposited in the Universidad Nacional Autonoma de México (UNAM).

Tribe Discocerinini Cresson

Discocerinini Cresson, 1925:228. Type genus: *Discocerina* Macquart, 1835.—Mathis and Zuyin, 1989:435 [diagnosis of tribe].—Mathis and Zatwarnicki, 1995:163–186 [world catalog].

Diagnosis.—A tribe of the subfamily Gymnomyzinae that is distinguished from other tribes by the following combination of characters:

Head: Frontal vitta (or ocellar triangle) mostly bare of setulae, not conspicuously setulose; ocellar setae well developed, inserted anterolaterad of anterior ocellus; reclinate fronto-orbital seta inserted anteromediad of proclinate fronto-orbital (if 2 proclinate fronto-orbitals present, reclinate seta inserted anteromediad of the larger, posterior, proclinate seta); pseudopostocellar setae well developed, proclinate, and slightly divergent, usually at least half length of ocellar setae. Pedicel bearing a large seta anterodorsally; arista bearing 4–6 dorsal rays, inserted along length of arista. Face generally shallowly arched, frequently more prominent at level of dorsal facial setae, not conspicuously pitted, rugose, tuberculate, or carinate. Gena generally short (secondarily high in some species), bearing setulae (including midportion) and 1 large seta, its posterior (postgenal) margin rounded, not sharp. Oral opening and clypeus narrow; mouthparts generally dark colored.

Thorax: Mesonotum generally microtomentose, frequently densely so, although variable; dorsocentral setae weakly developed, only posteriormost pair conspicuous; acrostichal setulae in 2–4 rows, frequently with a prescutellar pair better developed; postsutural supra-alar seta usually evident although sometimes reduced or absent; prescutellar acrostichal setae inserted approximate and behind alignment of posteriormost dorsocentral setae; scutellar disc usually densely setulose; scutellum bearing 2 large, marginal setae; notopleural setae 2, inserted at same level near ventral margin; anepisternum with 2 subequal setae inserted along posterior margin. Wing with vein R_{2+3} long, extended nearly to level of apex of vein R_{4+5}. Foreleg normally developed, not raptorial with greatly enlarged femur.

Abdomen: Male terminalia: Cerci paired, hemispherical, setose, bearing sides of rectum; epandrium U-shaped, encircling cerci, anterior margin rounded, in lateral view with setae mainly on dorsum and along anteroventral margin; dististyli lacking or fused indistinguishably with epandrium; posterolateral arms of epandrium attached with ventral apex of gonites, middle of posterior margin a base for aedeagal apodeme; aedeagal apodeme situated under aedeagus, associated with hypandrium and with ventral part of base of aedeagus, ventral margin with lobate appendix providing attachment for genital muscles that move aedeagus; gonite paired, connecting sides of base of aedeagus and laterodorsal margin of epandrium, bearing 1 or some setulae; aedeagus tubular, tapered anteriorly; ejaculatory apodeme as a spatula against background of ductus ejaculatorius.

Discussion.—In our classification for the family Ephydridae (Mathis and Zatwarnicki 1995), the subfamily Gymnomyzinae Latreille comprises six tribes, including Discocerinini. The latter is the most speciose of the tribes, with 144 of the 346 species presently included in Gymnomyzinae. There are eight genera in Discocerinini, and all eight occur in the New World and are included in the annotated key that follows.

ANNOTATED KEY TO NEW WORLD GENERA AND SUBGENERA OF DISCOCERININI

1. Face with secondary series of dorsolaterally inclined setae laterad to primary series . . . . *Polytrichophora* Cresson
[18 species worldwide; 7 New World species, presently being revised (Mathis, in preparation)]
– Face with secondary series of setae lacking or suggested only by medially inclined setulae . . 2
2. Notopleuron bare of setulae 3
– Notopleuron setulose in addition to 2 large setae 7
3. Forefemur slightly enlarged, bearing distinct row of stout, short setae along apical half of posteroventral surface . . . . *Pectinifer* Cresson
[Monotypic; *P. aeneus* (Cresson), New World tropics]
– Forefemur normally developed, lacking row of short, stout setae along posteroventral surface 4
4. Postsutural supra-alar seta strong, distinct, longer than posterior notopleural seta. Face with upcurved seta at lower lateral extremity . . . . *Diclasiopa* Hendel
[5 species worldwide; a single New World species, *D. lacteipennis* (Loew)]
– Postsutural supra-alar seta very short or absent, if distinguishable distinctly shorter than posterior notopleural seta. Face without upcurved seta at lower lateral extremity 5
5. Hind tibia with a preapical, ventral, spurlike seta; facial series comprising 2–3 large setae, dorsal seta inserted slightly medially from other setae and arising from distinct, shiny papilla, with a small, slightly dorsoclinate seta laterad of dorsal seta; generally microtomentose, cinereous species, appearing dull . . . . *Hecamedoides* Hendel
[23 species worldwide; a single New World species, *H. unispinosus* (Collin)]
– Hind tibia lacking a preapical, ventral spurlike seta; facial series comprised of 2 large setae, dorsal seta not arising from a shiny papilla and lacking a smaller seta laterad of dorsal seta; mostly bare to sparsely microtomentose, shiny to subshiny species 6
6. Face rather flattened, antennal grooves not always sharply defined ventrally; facial series of setae inserted very close to parafacials, dorsalmost seta not appreciably more removed mesad than ventral seta . . . . *Gymnoclasiopa* Hendel
[25 species worldwide; 8 Nearctic species]
– Face rather prominent at level of dorsal facial setae, sometimes transversely carinate; antennal grooves generally sharply defined ventrally . . . . *Ditrichophora* Cresson
[39 species worldwide; 7 Nearctic species, 2 Neotropical species]
7. Gena and lower part of parafacial broad; lateral margin of abdomen usually with gray to whitish microtomentose areas, these usually wedge shaped . . . . *Hydrochasma* Hendel
[6 species worldwide, all in the New World]
– Gena and parafacial rather narrow; abdomen lacking wedge-shaped, light-colored areas laterally (genus *Discocerina* Macquart) 8
[28 species worldwide in 3 subgenera]
8. Parafacial bearing setulae . . . . subgenus *Discocerina* Macquart
[9 species worldwide; 7 New World species]
– Parafacial lacking setulae 9
9. Facial series of setae 2, these well separated, distance between subequal to length of 1st fla-

gellomere; parafacial very narrow at anteroventral margin of eye; postsutural supra-alar and prescutellar acrostichal setae greatly reduced or lacking . . . . . . subgenus *Basila* Cresson [8 species worldwide, all in the New World]

– Facial series of setae 3–4, distance between setae conspicuously less than length of 1st flagellomere; parafacial evenly evident throughout length; postsutural supra-alar and prescutellar acrostichal setae present . . . . subgenus *Lamproclasiopa* Hendel [11 species worldwide; 9 New World species]

Genus *Ditrichophora* Cresson

Ditrichophora Cresson, 1924:159. Type species: *Ditrichophora exigua* Cresson, 1924, original designation.—Mathis and Zatwarnicki, 1995:169–174 [world catalog].

Strandiscocera Duda, 1942:15. Type species: *Discocerina nigrithorax* Becker, 1926, original designation.—Papp, 1979: 100 [synonymy].

Diagnosis.—Small to medium-sized shore flies, length 1.25–3.10 mm; generally mostly bare to sparsely microtomentose, shiny to subshiny species.

Head: Face rather prominent at level of dorsal facial seta, sometimes transversely carinate; antennal grooves generally sharply defined ventrally; face lacking secondary series of setae; facial setae usually 2–3, dorsal seta not arising from shiny papilla, lacking an upcurved seta at lower lateral extremity; parafacial narrow throughout length, lacking setulae; gena generally low. Eye generally oval, moderately conspicuously microsetulose, bearing several interfacetal setulae.

Thorax: Postpronotal and presutural supra-alar setae well developed; postsutural supra-alar seta reduced or lacking; notopleuron bare of setulae but bearing 2 larger setae; anterior notopleural seta inserted closer to posterior notopleural seta than to postpronotal seta. Forefemur normally developed, lacking row of short, stout setae along posteroventral surface; hindtibia lacking a preapical, ventral, spurlike seta.

Abdomen: Abdomen usually unicolorous, lacking wedge shaped, light colored areas laterally. Fourth tergum of ♂ only slightly longer than 3rd. Male terminalia as follows: epandrium complete dorsally, although sometimes attenuated, usually wider ventrally, especially in lateral view; cercus hemispherical or elongate (3× as long as wide), more narrowly pointed dorsally, not fused anteriorly with epandrium; aedeagus either simple, mostly tubular, in lateral view cigar shaped, ovate, or tapered toward apex or bifurcate apically (best seen in lateral view) with both lobes large; aedeagal apodeme situated behind aedeagus, curved, keel variously shaped; gonite variously shaped but generally pointed apically, bearing a subapical or apical setula; ejaculatory apodeme present, L-shaped; hypandrium turned up anteriorly, in lateral view irregularly curved.

Discussion.—The two Neotropical species described below are apparently closely related, both having small, crescent-shaped indentations on each side of the anterior portion of the frons above the antennal bases. Moreover, the structures of the male terminalia, especially the external male terminalia (epandrium and cerci), are very similar.

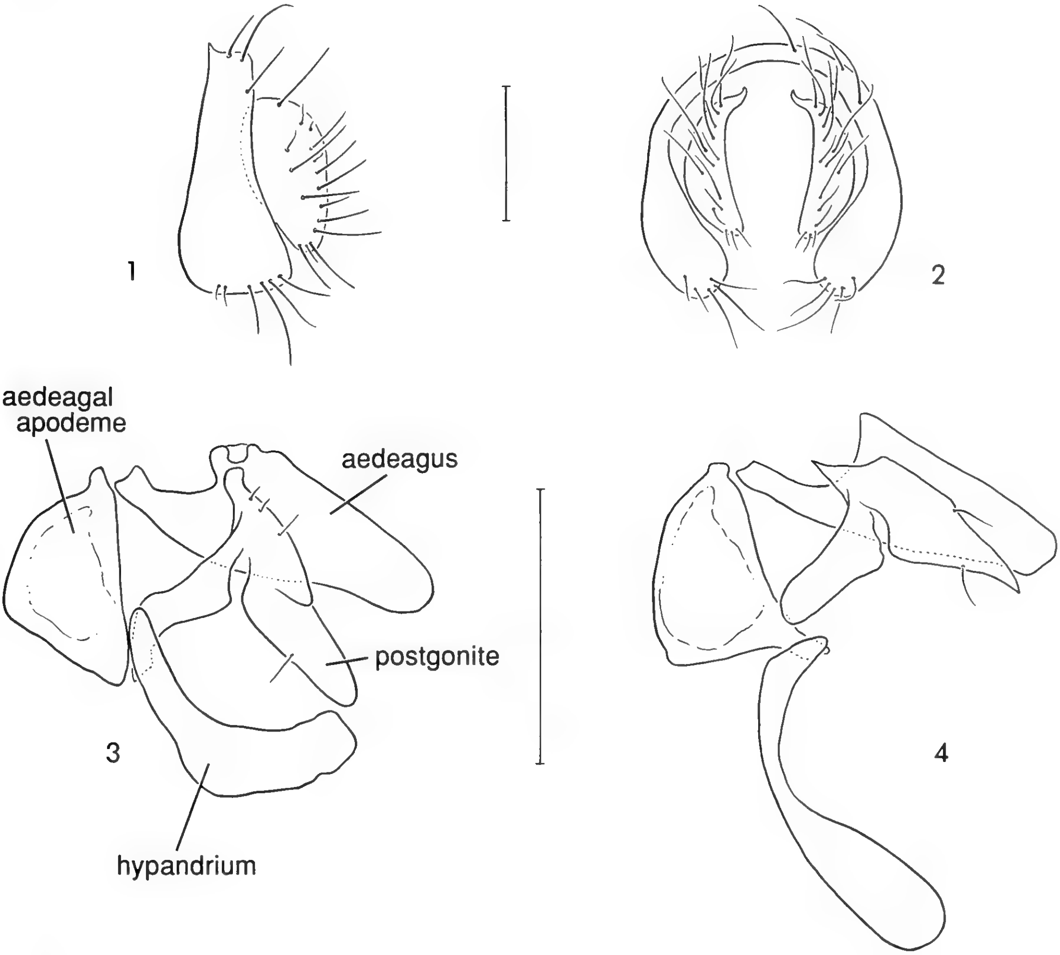
KEY TO NEOTROPICAL SPECIES OF *DITRICHOPHORA*

1. Postpronotum and notopleuron of male generally bare of microtomentum, shiny, similar to mesonotum and anepisternum; prescutellar acrostichal setae well developed; male with anterior third of frons bare of microtomentum, shiny black . . . . *D. chiapas,* new species

– Postpronotum and most of notopleuron of male densely invested with fine, brown microtomentum, contrasted sharply with generally shiny, adjacent mesonotum and anepisternum; prescutellar acrostichal setae weakly developed; frons of male generally sparsely microtomentose to anterior margin . . . *D. bella,* new species

***Ditrichophora bella* Mathis, New Species**
(Figs. 1–3)

Description.—Small to medium-sized shore flies, length 1.90–3.10 mm; generally shiny black.



Figs. 1–4. 1–3; *Ditrichophora bella.* 1, External male terminalia (epandrium and surstyli), lateral view. 2, Same, posterior view. 3, Internal male terminalia (postgonite, pregonite, hypandrium, aedeagal apodeme, aedeagus), lateral view. 4, *Ditrichophora chiapas,* Internal male terminalia (postgonite, pregonite, hypandrium, aedeagal apodeme, aedeagus), lateral view. Scale = 0.1 mm.

Head: Frons of male generally moderately microtomentose to anterior margin, only small, linear patch anterolaterally and at base of setae bare of microtomentum; frons of female with small bare areas anteriorly; 1 proclinate, fronto-orbital seta, inserted just behind and laterad of reclinate seta. Antenna black; apical margin of pedicel and 1st flagellomere invested with whitish gray microtomentum; arista bearing 5 dorsal rays. Face bearing 2 lateral, facial setae, dorsal seta inserted at level of facial prominence, ventral seta inserted toward ventral margin, distance between facial setae about equal to length of 1st flagellomere; face black but mostly invested with silvery white microtomentum, only ventral portion of antennal grooves, vertical stripe immediately adjacent to parafacial, and median stripe that curves laterally ventrally bare, shiny, black; parafacial completely microtomentose, whitish gray. Gena-to-eye ratio 0.1–0.13. Mouthparts, including maxillary palpus, black.

Thorax: Mesonotum generally sparsely microtomentose, golden brown, becoming sparser to bare laterally, through supra-alar area, thereafter laterally sparsely microtomentose, male bearing a very distinctive stripe of dense, fine, brown microtomentum extended from postpronotum through most of notopleuron, female shiny black, similar to adjacent areas; prescutellar acrostichal setae weakly developed. Wing hyaline; costal ratio 0.37–0.44; M vein ratio 0.60–0.63. Legs except tarsi black, mostly shiny, femora with some surfaces very sparsely microtomentose; tarsi yellow except apical 2 brown; forefemur unadorned with short, peglike setulae along posteroventral surface. Halter white.

Abdomen: Black, generally shiny, especially laterally and ventrally. Male terminalia (Figs. 1–3): Epandrium broadly rounded dorsally in posterior view (Fig. 2), narrowed dorsally, becoming wider ventrally, ventral margin bluntly rounded in lateral view (Fig. 1); cerci lunate in posterior view (Fig. 2); aedeagus in lateral view slipperlike, with toe or apex comparatively narrowly rounded (Fig. 3); aedeagal apodeme more or less triangular in lateral view; postgonite and pregonite fused basally; postgonite with 2–3 setulae along basoposterior margin and 1 setula along margin toward hypandrium, apex narrowly rounded in lateral view (Fig. 3); hypandrium broadly rounded along anterior margin, angularly notched medially with 2 arms attached to aedeagal apodeme.

Type material.—The holotype ♂ is labeled "DOMINICAN RP. Monsñ. Nouel: nr. Jima, 670 m, 19°01.2′N, 70°28.8′W[,] 10 May 1995, W. N. Mathis/HOLOTYPE Ditrichophora bella ♂ W. N. Mathis USNM [red; species name and gender handwritten]." The holotype is double mounted (minuten in block of plastic), is in excellent condition, and is in the USNM. The allotype and 24 paratypes (14 ♂, 10 ♀; USNM) bear the same locality label as the holotype. Other paratypes are as follows: JAMAICA. *St. Andrew:* Hardwar Gap (18°04.2′N, 76°44′W), 17 May 1996, D. and W. N. Mathis, H. Williams (1 ♂, 1 ♀; USNM). MEXICO. *Chiapas:* El Triunfo (49 km S Jaltenango; 1800 m), 14 May 1985, W. N. Mathis (1 ♂; USNM).

Distribution.—Neotropical: Mexico (CHI), West Indies (Dominican Republic, Jamaica).

Diagnosis.—This species is distinguished from congeners, especially *D. chiapas,* by the following combination of characters: Postpronotum and most of notopleuron of male densely invested with fine, brown microtomentum, contrasted sharply with generally shiny, adjacent mesonotum and anepisternum; prescutellar acrostichal setae weakly developed; frons of male generally sparsely microtomentose to anterior margin; halter white; only 1 proclinate frontoorbital seta; and pattern of silvery white microtomentum on face (see species description).

Etymology.—The species epithet, *bella,* meaning "pretty, lovely, fine," is of Latin derivation and refers to the external attributes of this species.

Remarks.—All specimens were collected in montane habitats that were frequently overcast if not enshrouded in a foggy mist. The specimens from the Dominican Republic were mostly collected from a pile of spoiling cabbage that had been discarded on the roadside.

This species is sexually dimorphic, with the male have the stripe of dense but fine microtomentum extended from the postpronotum to the posterior margin of the notopleuron. Females are shiny black throughout this area of the pleuron, similar to portions of the mesothorax that are immediately adjacent.

Ditrichophora chiapas Mathis, New Species

(Fig. 4)

Description.—Moderately small shore files, length 2.0–2.65 mm; generally shiny black.

Head: Frons of male and female similar, moderately microtomentose on posterior portion, although bare at bases of setulae and small area just laterad of posterior ocelli, anterior third of frons bare, shiny, with

2 lunate indentations, median area with pointed extension of moderately microtomentum from posterior portion; 1 proclinate, fronto-orbital seta, inserted just behind and laterad of reclinate seta. Antenna black; apical margin of pedicel and 1st flagellomere invested with whitish gray microtomentum; arista bearing 5 dorsal rays. Face bearing 3 lateral, facial setae, dorsal seta longest, inserted at level of facial prominence, ventral setae progressively shorter, evenly spaced with distance between less than width of 1st flagellomere; face mostly black, shiny, but with pattern of silvery white microtomentose, vertical stripes; lateral facial stripe immediately adjacent to parafacial, other vertical stripe just laterad of midfacial vertical bare area; also silvery white microtomentose on dorsal portion of antennal grooves and along ventral, facial margin; parafacial bare, shiny black. Gena-to-eye ratio 0.1–0.12. Mouthparts, including maxillary palpus, black.

Thorax: Mesonotum generally sparsely microtomentose, golden brown, becoming bare laterally through supra-alar area and continuing ventral through pleural area; prescutellar acrostichal setae well developed. Wing hyaline; costal ratio 0.40–0.43; M vein ratio 0.70–0.73. Legs except tarsi black, mostly shiny, femora with some surfaces very sparsely microtomentose; tarsi yellow except apical 1–2 brown; forefemur with row of numerous, very short, peglike setulae along posteroventral surface. Halter white.

Abdomen: Black, generally shiny, especially laterally and ventrally. Male terminalia (Fig. 4): Epandrium and cerci as in *D. bella*; aedeagus in lateral view slipperlike, with toe or apex comparatively bluntly rounded (Fig. 4); aedeagal apodeme more or less triangular in lateral view (Fig. 4); postgonite and pregonite fused basally; postgonite with 1 setula along basoposterior margin and 1 setula along margin toward hypandrium, apex acutely rounded in lateral view (Fig. 4); hypandrium broadly rounded along anterior margin, angularly notched medially with 2 arms attached to aedeagal apodeme.

Type material.—The holotype ♂ is labeled "MEXICO. Chiapas: El Triunfo (49 km S Jaltenango) 14 May 1985, 1800 m[,] Wayne N. Mathis/HOLOTYPE Ditrichophora chiapas W. N. Mathis USNM [red; species name handwritten]." The holotype is double mounted (minuten in block of plastic), is in excellent condition, and is in the USNM. The allotype ♀ and four paratypes (4 ♂; USNM) bear the same locality label as the holotype. Other paratypes are as follows: MEXICO. Chiapas: El Triunfo (49 km S Jaltenango; 1300–2000 m), 13–15 May 1985, W. N. Mathis (3 ♂; UNAM, USNM).

Distribution.—Neotropical: Mexico (CHI).

Diagnosis.—This species is distinguished from congeners, especially *D. bella,* by the following combination of characters: Postpronotum and notopleuron of male generally bare of microtomentum, shiny, similar to mesonotum and anepisternum; prescutellar acrostichal setae well developed; male with anterior third of frons bare of microtomentum, shiny black; halter white; only 1 proclinate fronto-orbital seta; and pattern of silvery white microtomentum on face (see species description).

Etymology.—The species epithet, *chiapas,* refers to the Mexican state where the type series was collected and is treated as a noun in apposition.

Remarks.—El Triunfo is a site in the cloud forest of southern Mexico (some of the only cloud forest that remains largely undisturbed in Mexico).

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NEW SPECIES AND HOST PLANTS OF THE *ANTHONOMUS GRANDIS* SPECIES GROUP (COLEOPTERA: CURCULIONIDAE)

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Abstract.—Three new species of the *Anthonomus grandis* group are described and illustrated, and a key distinguishing the five species of the group is presented. ***Anthonomus townsendi,* n. sp.,** and ***A. palmeri,* n. sp.,** occur in the State of Chiapas, México, and ***A. mallyi,* n. sp.,** occurs in Costa Rica. Host plants of these species are members of the genus *Hampea* (Malvales: Malvaceae). The taxonomic and ecological interrelationships of the weevil taxa and their malvaceous hosts are discussed.

Key Words: Curculionidae, *Anthonomus,* new species, México, Costa Rica, *Hampea* hosts

Since the boll weevil, *Anthonomus grandis* Boheman, was first recognized as a pest of cotton in the late 1800's considerable effort has been expended in attempts to understand its origin, systematics, and host relationships (Burke et al. 1986). Until recently, the lack of knowledge of relatives of the boll weevil hindered meaningful comparative studies of its phylogeny and ecology. *Anthonomus hunteri* Burke and Cate, the first species recognized as having close morphological affinities to *A. grandis,* was described in 1979 (Burke and Cate 1979). Before the present study, these were the only two known species of the *A. grandis* group as defined by Clark and Burke (1986). Three new species are added to the group in the present paper.

Both of the previously known species of this group are almost entirely restricted to larval development on certain Malvaceae of the tribe Gossypieae, including *Gossypium, Hampea, Cienfuegosia,* and *Thespesia. Anthonomus hunteri* is known to develop only on *Hampea trilobata* Standley, a plant endemic to the Yucatan Peninsula, Belize and northern Guatemala, while *A. grandis* has a wider host range within Gossypieae (Burke et al. 1986, Cross et al. 1975, Fryxell and Lukefahr 1967, Fryxell 1969). *Anthonomus grandis* was thought to be specific to Gossypieae until Bodegas et al. (1977) discovered members of the species developing on *Hibiscus pernambucensis* Arruda of the tribe Hibisceae in Chiapas, México.

A growing body of evidence indicates that *Hampea* is the ancestral host plant genus of the *A. grandis* species group. Both previously known species of the group utilize *Hampea* as hosts, and *A. hunteri* develops exclusively on *H. trilobata.* The three new species of the *A. grandis* group described herein also utilize species of *Hampea* as hosts. Further evidence of an ancestral relationship of the weevils with plants of the genus *Hampea* includes the following: 1) large populations of *A. grandis* occur on *Hampea nutricia* Fryxell in southern México in the absence of cultivated or wild cotton; 2) the parasite guild of weevils on *Hampea* is more diverse than that for weevil populations on cotton (Burke et al. 1986, Cate et al. 1990); and, 3) *A. grandis* and *A. hunteri* have behavioral adaptations apparently specific to *Hampea* plants that suggest long periods of association (Stansly 1985).

Since *Hampea* has been shown to be the likely original host genus of the boll weevil, considerable interest has been generated regarding the ecology of these plants and their interactions with weevils. *Hampea* contains 21 described species from both the Gulf and Pacific coasts of México and southward into Colombia, with the greatest species diversity occurring in Chiapas, México and Guatemala (Fryxell 1969, 1979). Only four species of *Hampea* have been previously reported as hosts of *Anthonomus,* three of these being utilized by *A. grandis* and one by *A. hunteri.* Nine additional species of *Hampea* were examined during the present study. Four of these were found to serve as hosts of three heretofore undescribed species of the *A. grandis* group. With the *A. grandis* species group now being comprised of five species, it is possible to conduct a detailed comparison of the these taxa to assist in analyzing their origin, ecology, and host and phylogenetic relationships. The objectives of the present paper are to describe the three new species, compare them with their previously known relatives, and to report on the current status of eight species of *Hampea* in México and Central America as hosts of members of the *A. grandis* species group. A cladistic analysis of both the weevils and their *Hampea* hosts is underway. Additional papers on the ecology and genetics of this weevil group are also being prepared.

METHODS AND MATERIALS

Determination of the status of species of Hampea as hosts of Anthonomus.—During the years 1987–1990, 1992, and 1995 nine species of *Hampea* not previously known to be hosts of *Anthonomus* were examined for evidence of weevil infestations in México, Guatemala, Belize, and Costa Rica. Examined were: *Hampea appendiculata* (J. Donnell-Smith) Standley, *Hampea bracteolata* Lundell, *Hampea integerrima* Schlechtendal, *Hampea longipes* Miranda, *Hampea mexicana* Fryxell, *Hampea montebellensis* Fryxell, *Hampea platanifolia* Standley, *Hampea stipitata* S. Watson, and *Hampea tomentosa* (K. Presl) Standley. These species were located in the field on the basis of distributional records obtained from specimens in the following herbaria: United States Department of Agriculture Cotton Laboratory, College Station, TX; Herbario Nacional, Universidad Autónoma de México, México, D.F.; and University of Texas, Austin, TX. Paul A. Fryxell (pers. comm.), specialist on the systematics of this group, also provided additional information useful in locating the plants. Each tree was examined for the presence of weevils and for evidence of feeding and oviposition both on the tree and in fallen flower buds. Potentially infested buds were enclosed in vials in the laboratory to allow for emergence of adult weevils.

Comparisons and descriptions of weevils.—To establish the relationships of the weevils collected and reared during this study, it was necessary to compare specimens reared from *Hampea* with those from other malvaceous hosts. A total of 761 adults of the *A. grandis* species group from 13 species of Malvaceae was examined. In addition to weevils from eight species of *Hampea,* material was studied from *Gossypium hirsutum* L., *Gossypium thurberi* Todaro, *Cienfuegosia rosei* Fryxell, *Cienfuegosia drummondii* A. Gray, and *Hibiscus pernambucensis* Arruda.

Comparisons were made between adult weevils from the entire range of known hosts plants. Characters used by Burke (1986) and Burke et al. (1986) to distinguish the three recognizable forms of *A.*

grandis (Southeastern, Mexican, and Thurberia), and by Clark and Burke (1986) in a phylogenetic study of the *A. grandis* group were used here. Characters examined included the shape and arrangement of pronotal and elytral scales, shape of profemur, shape and alignment of scutellum, coloration of antennae, and size and shape of body. The male median lobe proved to be especially useful in distinguishing species of the group. Analysis of specimens of *A. grandis* reared from various host plants aided in evaluation of the effects of these hosts on the general morphology and intraspecific variation within the species group. A considerable amount of previously accumulated information on host-induced and geographic variation of *A. grandis* provided a basis for comparison and evaluation of the taxonomic status of the newly collected weevils on *Hampea.*

Measurements were made with an eyepiece micrometer in a stereoscopic microscope. The size of the weevils was determined in a lateral view by measuring from the anterior margin of the eye to the apex of the elytra. The length of the rostrum was determined by measuring the chord from the lower anterior margin of the eye to the apex of the rostrum. Other structures were measured at the point of their greatest length or width.

RESULTS

Host plants.—Weevils of the *A. grandis* group were reared from four species of *Hampea* not previously reported as hosts: *H. appendiculata* (Coastal Plain of eastern Costa Rica); *H. longipes* (Central Highlands of Chiapas); *H. mexicana* (Central Depression of Chiapas); and *H. montebellensis* (eastern Chiapas). Five additional species of *Hampea* (*H. bracteolata, H. integerrima, H. platanifolia, H. stipitata,* and *H. tomentosa*) were examined but no weevils were found associated with these. Several relatively large populations of *H. stipiata* and *H. integerrima* proved to be uninfested during a period of two years of monitoring. Both of these species of plants were heavily laden with flower buds at the times of observation and, furthermore, they occurred within the flight range of *A. grandis* on *H. nutricia* in the states of Veracruz and Chiapas. Conditions appeared to be excellent for weevils to develop on these plants but accumulated evidence indicated that they did not do so. Because of their isolated distributions and relative rarity, only small populations of *H. platanifolia, H. bracteolata,* and *H. tomentosa* were found. Although the few trees observed were large and bore numerous flower buds, they were apparently not infested with weevils.

Definition of group.—*Anthonomus grandis, A. hunteri* and the three new species described herein are considered to be members of the same species group because of their close morphological and host plant affinities, although it is not possible to describe the group precisely on the basis of shared apomorphies. All of the species of the group develop in flower buds, and occasionally fruits, of Malvaceae of the tribe Gossypieae. In addition to its cotton tribe hosts, one population of *A. grandis* develops on *Hibiscus pernambucensis,* tribe Hibisceae. The latter association is apparently the result of a recent, localized host shift which should not detract from the fact that the members of the group obviously evolved on closely related hosts in the tribe Gossypieae, probably in the genus *Hampea.* The weevils of this group are also of a relatively large size for the genus, generally averaging approximately 4 to 5 mm in length and are occasionally larger. There are other tropical anthonomines of similar or larger size, for example in the genus *Loncophorus,* but the relationship of these to *Anthonomus,* and specifically to the *A. grandis* group, has not been determined (see Clark 1988, 1995, for further discussion of this problem). Furthermore, known hosts of species of *Loncophorus* are all members of the families Bombacaceae and Tiliaceae. While these plant families are closely related to Malvaceae we do not believe that this, in itself, is sufficient evidence to closely ally *Lonchophorus* and the *A. grandis* group. In addition to the characters mentioned above that are shared by species of the *A. grandis* group, they have similar subconical heads, coarse hair-like to scale-like setae that are more-or-less evenly distributed over the body, rounded sides of the elytra as compared with the wedge-shaped or "navicular" elytra characteristic of most *Lonchophorus,* and do not have prothoracic postocular lobes as do species of the latter genus. The *A. grandis* group was compared to the subgenus *Anthonomorphus* Dietz of the genus *Anthonomus* by Clark and Burke (1986). Species of *Anthonomorphus* also develop on malvaceous plants, but unlike the *A. grandis* group, their hosts are in the tribe Malveae. In addition, the two groups differ in several morphological characters, most notably in the shapes of the male mesotrochanters and median lobes. While *Anthonomorphus* and the *A. grandis* species group may not be sister groups, there is still sufficient evidence to warrant further consideration of their relationships. Clark (1995) suggested that *Lonchophorus, Anthonomorphus,* and the *A. grandis* species group may constitute a monophyletic lineage confined to the Malvales. Additional study of certain Neotropical members of the tribe Anthonomini, especially the species of *Lonchophorus* and its allies, is needed to help clarify the overall relationships of species of the *A. grandis* group. Pending such a study, size, general habitus, vestiture, and narrow host ranges restricted almost entirely to plants in the tribe Gossypieae are used here to define the group.

KEY TO SPECIES

1. Rostrum slightly to moderately strongly carinate dorsally; hirsute only at base or may be nearly to completely bare; female rostrum slightly to moderately strongly curved (Figs. 3, 4, 5, 6). Elytral vestiture usually arranged in an orderly manner, with individual setae directed posteriorly. Male median lobe moderately to strongly curved in lateral view (Figs. 23, 24, 26, 27). Protibia slightly to moderately strongly sinuate on inner margin 2

– Rostrum strongly carinate and hirsute dorsally from base to antennal attachments; female rostrum nearly straight (Fig. 1). Elytral vestiture arranged in irregular manner, with individual setae often directed obliquely or laterally. Male median lobe broadly rounded at apex; slightly curved ventrally in lateral view (Fig. 25). Protibia strongly sinuate on inner margin. Hosts *Hampea mexicana* and *H. latifolia.* Central and southern Chiapas, México, above 500 m . . . . *A. townsendi* Jones and Burke, n.sp.

2. Rostrum of female slender; dorsal carinae poorly defined. Antennae of female attached at or near middle of rostrum. Male median lobe slightly (Fig. 24) to strongly (Fig. 26) constricted before tip 3

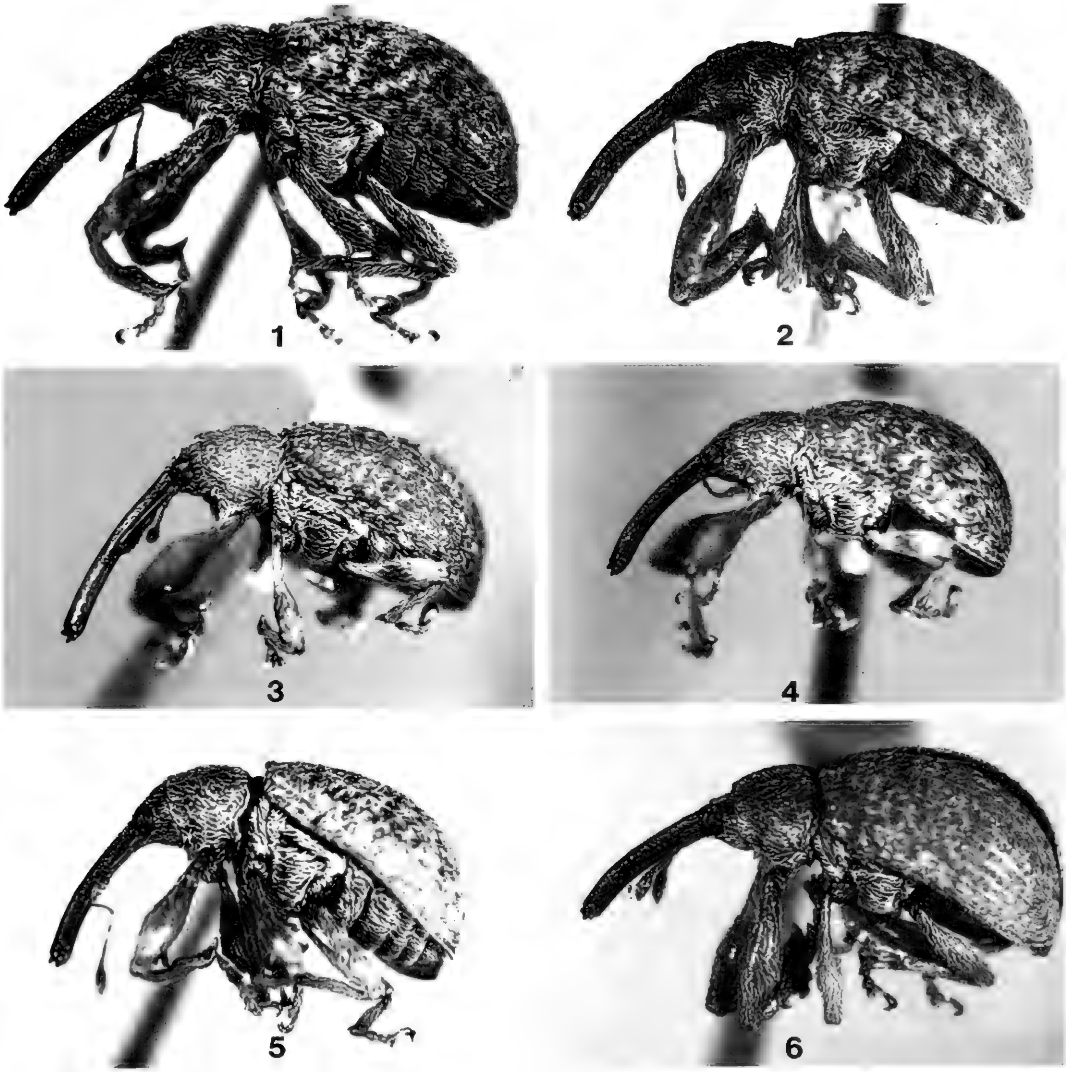
– Rostrum of female stouter; dorsal carinae moderately strongly developed. Antennae of female usually attached well before middle of rostrum. Male median lobe broadly rounded to somewhat pointed at tip, but sides not constricted (Figs. 23, 27) 4

3. Rostrum of both sexes moderately strongly curved. Profemur slender, length/width ratio 4.2–4.7. Male median lobe with sides slightly constricted before apex (Fig. 24). Host *Hampea trilobata.* Yucatan Peninsula, México, and Belize . . . . *A. hunteri* Burke and Cate

– Rostrum of both sexes slightly curved (Figs. 3, 4). Profemur stouter, length/width ratio 3.0–3.5. Male median lobe strongly constricted before apex (Fig. 26). Host *Hampea appendiculata.* Costa Rica . . . . *A. mallyi* Jones and Burke, n. sp.

4. Median vitta of setae on pronotum well defined. Setae on procoxae and sides of prothorax scale-like, with blunt apices (Figs. 18, 22). Male median lobe moderately strongly curved in lateral view; sides of apical portion converging strongly to blunt tip; length/width ratios of apical portion (measured from retracted phallotreme to tip) 1.2–1.7 (Fig. 23). Hosts *Gossypium* spp., *Cienfuegosia* spp., *Thespesia populnea, Hibiscus pernambucensis, Hampea nutricia, H. rovirosae,* and *H. latifolia.* United States, México, Central America, Venezuela, Colombia, Brazil, and Argentina . . . . *A. grandis* Boheman

– Median vitta of setae on pronotum absent or poorly defined; setae on procoxae and sides of prothorax narrow, with apices sharply pointed (Figs. 17, 21). Male median lobe slightly curved in lateral view; sides of apical portion broadly rounded to tip; length/width ratios of



Figs. 1–6. 1, *Anthonomus townsendi,* female. 2, *A. townsendi,* male. 3, *Anthonomus mallyi,* female. 4, *A. mallyi,* male. 5, *Anthonomus palmeri,* female. 6, *A. palmeri,* male.

apical portion 0.7–1.0 (Fig. 27). Hosts *Hampea montebellensis* and *H. longipes.* Central Highlands and eastern Chiapas, México, above 1000 m . . . . . *A. palmeri* Jones and Burke, n. sp.

SPECIES DESCRIPTIONS

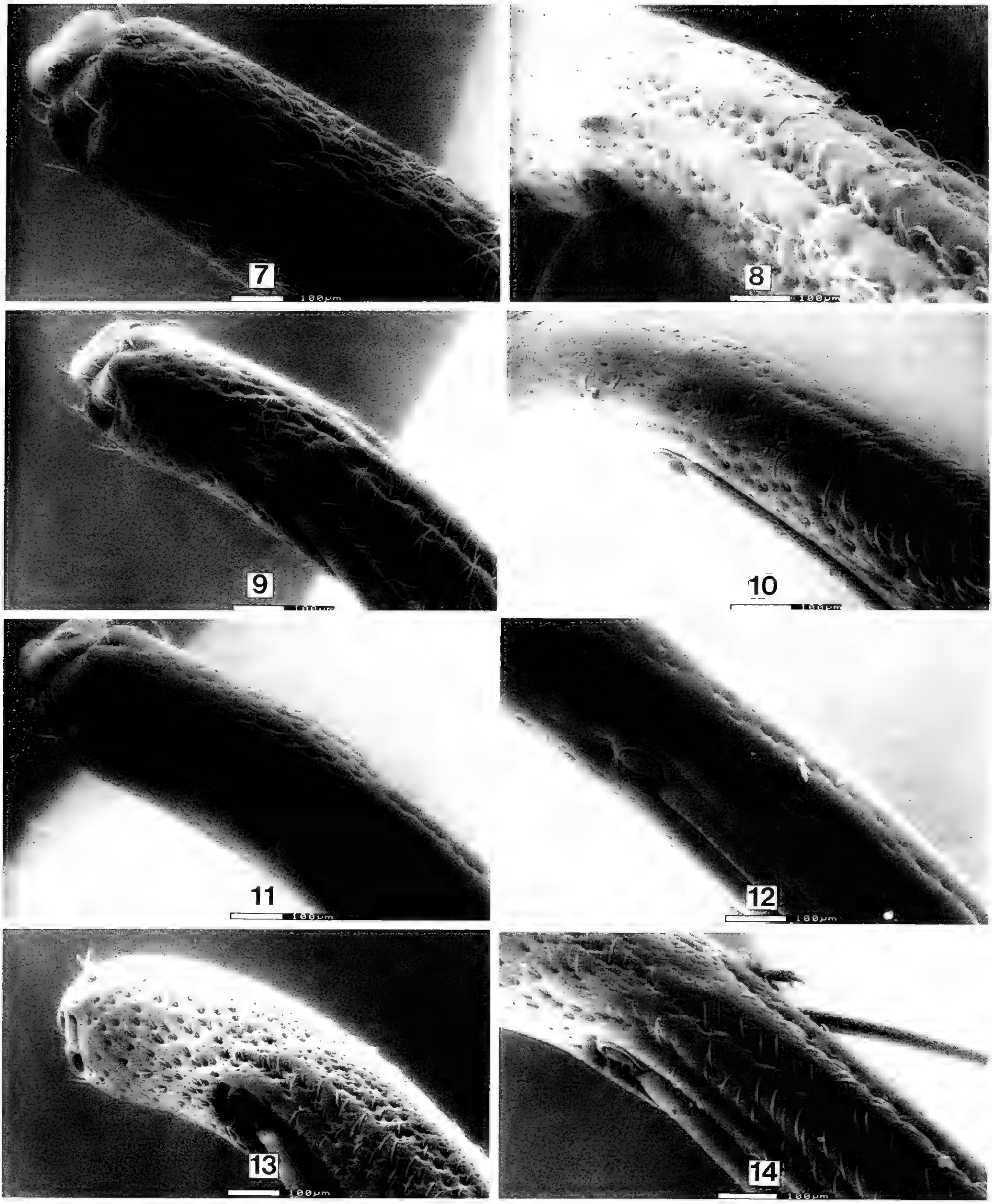
Anthonomus townsendi **Jones and Burke, NEW SPECIES**

(Figs. 1, 2, 7, 8, 15, 19, 23)

Body oblong-oval; length 4.17–6.25 mm (x = 5.62, n = 30); width 1.92–2.92 mm (x = 2.60, n = 30). Integument shining, dark brown; head and rostrum sometimes darker than thorax and abdomen. Vestiture of coarse, recumbent, straw-colored pubescence; arranged in irregular patches on elytra (Figs. 1, 2); concentrated along midline of pronotum; elsewhere on prothorax fine and slightly broader setae intermixed; on underside and legs pubescence uniformly distributed. *Rostrum* of both sexes feebly curved, that of male (Fig. 2) being slightly more strongly curved than female (Fig. 1); ca. 2× longer than prothorax along midline in both sexes. Median and lateral rostral carinae strongly developed in male, less so in female; carinae and associated pubescence of male extending from base past antennal insertion (Fig. 7), in female extending only to level of antennal insertion (Fig. 8). Distad of antennal insertion rostrum of male with deep, oval punctures, each bearing a seta longer than greatest diameter of puncture (Fig. 7), rostrum of female not as strongly punctate distally (Fig. 8). Eyes moderately convex in dorsal view; not free behind; separated in front by distance equal to ⅗ width of rostrum at base. Frons deeply foveate; moderately densely covered with fine coarse pubescence. *Antennae* attached ca. apical ¼ of rostrum of male, ca. apical ⅓ in female. Funicle 7-segmented, 1.7–2.2× longer than club; segment 1 slender, as long as next two segments combined; segment 2 slightly longer than 3 + 4. Club subequal to preceding five funicular segments combined; basal two segments loosely joined; apex sharply pointed. *Prothorax* with sides feebly rounded, subparallel in basal ⅔ then converging to subapical constriction; width at apex ½ width at base; integument shining, bearing large, rounded punctures that are smaller medially than laterally, areas between punctures smooth, bare, each puncture bearing an anteriorly projecting seta; vestiture concentrated into moderately dense median pronotal vitta, uniformly distributed laterally (Fig. 15) except slightly concentrated above coxae. *Scutellum* ca. 2× longer than wide, rounded in cross section, sides parallel in apical ½, expanding slightly at base; clothed above with appressed, fine scale-like setae that are concentrated in basal ⅓ and densely clothed at apex. *Elytra* strongly convex (Figs. 1, 2) in lateral view; slightly wider at base than prothorax; humeri moderately strongly rounded; sides subparallel to point past middle then strongly rounded to apex. Third elytral interval sometimes expanded basally. Pubescence arranged in regularly spaced patches presenting marmorate appearance, sometimes coalescing into more linear patterns towards elytral apex. Intervals fairly strongly convex, especially on basal ½ of elytra. *Ventral side* of body with pubescence on thorax coarse, more hair-like on abdominal sterna. Procoxae contiguous. Mesocoxae separated by distance equal to ca. ¼ width of coxa. Bare depression medially near posterior margin of metasternum. Abdominal sternum 1 along midline slightly longer than 2; sternum 3 ca. ⅓ longer than 4. *Legs* moderately stout (Figs. 1, 2); rather uniformly covered with coarse pubescence. Profemur 3.2–3.6× longer than broad; bearing two teeth, the proximal of which is distinctly larger than triangular distal tooth. Meso- and metafemur ca. equal in size, each bearing a small tooth. Protibia curved in basal ⅓ and sinuate on inner margin (Fig. 1); meso- and metatibia straight and less strongly sinuate on inner margins. Tarsal claws each bearing long, slender tooth, the apex of which reaches past middle of claw. *Median lobe* of male genitalia feebly curved in lateral view; apex broadly rounded, distance from retracted phailotreme to apex of median lobe less than width of median lobe (Fig. 25).

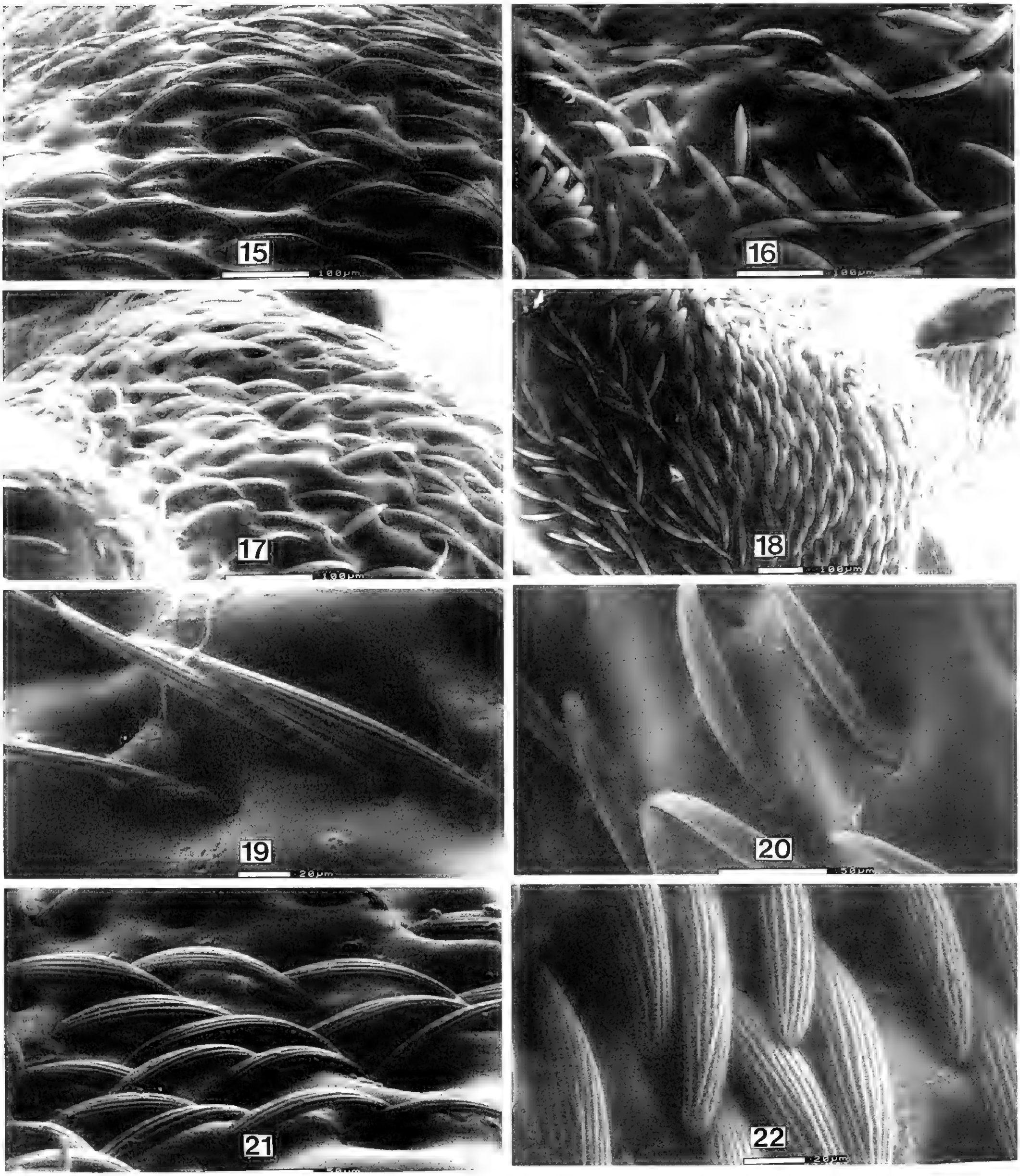
Type series.—Holotype ♂-México: 30 km N. D. Chanona, Chiapas, VI-29-1990, ex. *Hampea mexicana* (buds on ground), R. Jones. Paratypes (68): 9 ♂, 8 ♀ with same label data as holotype. México: 9 km N. Nvo. Tenochititlan, Mpio. Cintalapa, Chiapas, ex. *Hampea mexicana,* R. W. Jones (1 ♀, VII-23-1988; 4 ♂, 1 ♀, VI-12-1991; 2 ♂, 2 ♀, VI-28-1991; 6 ♂, 4 ♀, VII-12-1991). México: 5 mi. N. Nvo. Tenochititlan, Mpio. Cintalapa, Chiapas, VI-29-1990, ex. *Hampea mexicana,* R. W. Jones and D. Baro (11 ♂, 11 ♀). México: Jiquipilas, 4 mi W. Fco. Villa, Chiapas, VIII-6-1989, Jones, Cate and Krauter, ex. *Hampea mexicana* (1 ♂, 3 ♀). México: 19 km N. Mapastepec, Chiapas, VII-7, 1991, R. Jones, ex. *Hampea latifolia* ground buds (2 ♂, 1 ♀); 1 ♂, 1 ♀ same data as preceding except VIII-11-1991.

The holotype and some paratypes are deposited in the Insect Collection of the De-



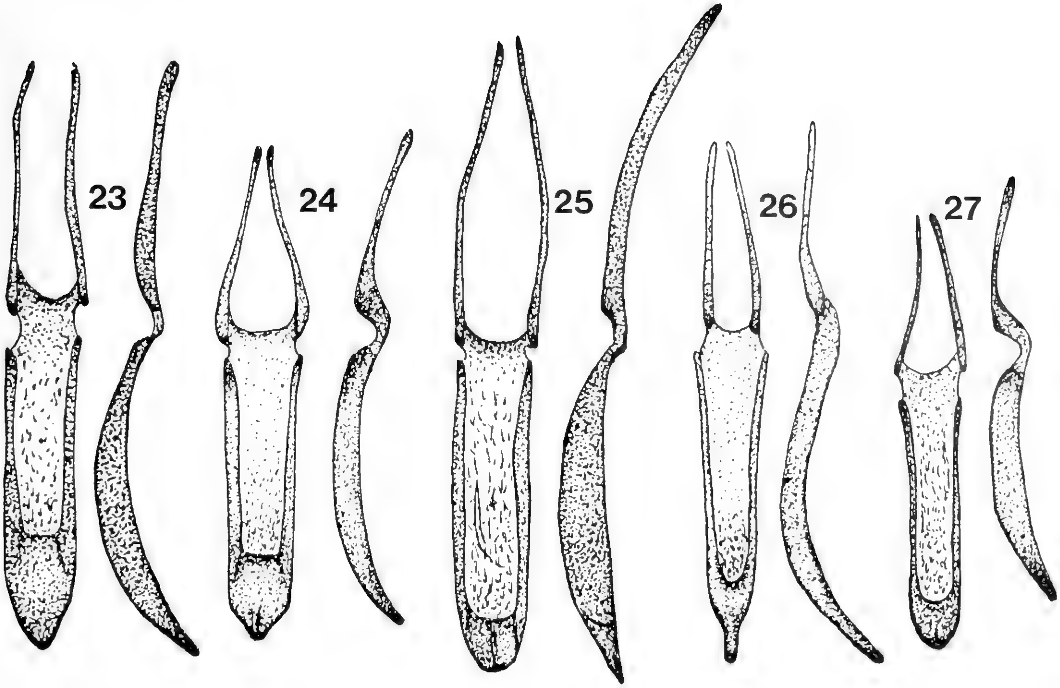
Figs. 7–14. Rostra of: 7, *Anthonomus townsendi*, male. 8, *A. townsendi*, female. 9, *Anthonomus palmeri*, male. 10, *A. palmeri*, female. 11, *Anthonomus mallyi*, male. 12, *A. mallyi*, female. 13, *Anthonomus grandis*, male. 14, *A. grandis*, female.

partment of Entomology, Texas A&M University. Paratypes are deposited in the collections of: Instituto de Biología, Universidad Autónoma de México, D.F.; El Colegio de la Frontera Sur, San Cristobal de las Casas, Chiapas, México; Auburn University; Canadian Museum of Nature, Ottawa, Canada; and Charles W. O'Brien.



Figs. 15–22. Ventral one-half of pleural region of prothorax of: 15, *Anthonomus townsendi.* 16, *Anthonomus mallyi.* 17, *Anthonomus palmeri.* 18, *Anthonomus grandis* (ex *Hampea nutricia*). Dorsal one-half of pleural region of prothorax (above base of procoxa) of: 19, *Anthonomus townsendi.* 20, *Anthonomus mallyi.* 21, *Anthonomus palmeri.* 22, *Anthonomus grandis* (ex *Hampea nutricia*).

Diagnosis and variation.—Characters differentiating species of the *A. grandis* group are presented in the key. In general, *A. townsendi* is larger and more robust than other species of the group. The marmorate appearance of the pubesence on the elytra is also distinctive. The female rostrum is less strongly curved than in the other species and the apical length (from antennal attachment to apex of rostrum) is distinctly



Figs. 23–27. Dorsal and lateral views of male median lobe of: 23, *Anthonomus grandis* (ex *Hampea nutricia*). 24, *Anthonomus hunteri.* 25, *Anthonomus townsendi.* 26, *Anthonomus mallyi.* 27, *Anthonomus palmeri.*

shorter relative to the rostrum width. The male rostrum of *A. townsendi* is the most densely hirsute of the members of the complex and also has the most strongly pronounced punctures and largest scales distad of the antennal insertion (Fig. 7). The protibia of *A. townsendi* is more strongly curved and the inner margin is more strongly sinuate than that of either *A. grandis, A. hunteri* or *A. mallyi.* The protibia of *A. palmeri* is curved basally like that of *A. townsendi* but as in other members of the group it is slender and the inner margin is not as sinuate. Furthermore, *A. townsendi* may be distinguished from the three recognized forms of *A. grandis* by the pubescence being uniformly distributed on the sides of the prothorax. The relatively straight median lobe in lateral view with the apex being wider than long also distinguishes this species from *A. grandis, A. hunteri,* and *A. mallyi.*

The major variation in the type series is in size. Specimens range from 4.2 to 6.3 mm in length. Teeth on the profemur show considerable variation in relative size. On some individuals the profemoral teeth are similar in size and shape to those of *A. grandis.* However, the smaller of the two profemoral teeth of *A. townsendi* is sometimes strongly reduced in comparison with the larger one. The larger profemoral tooth of *A. townsendi* is broader at the base than that of *A. grandis.* As is often the case with reared material, some of the individuals of the type series are somewhat teneral and are thus not as dark as would be expected of well hardened specimens.

Host plants.—Hosts of this species are *H. mexicana* in the Central Depression area of Chiapas, and *H. latifolia* on the slopes of the Sierra Madre de Chiapas above 500 m elevation. It is of interest to note that *H. latifolia* is also a host of *A. grandis* on the coastal plain near Tapachula, Chiapas. Specimens reared from the latter host population were clearly *A. grandis* and showed no overlap in distinguishing characters with

A. townsendi reared from *H. latifolia* in montane habitats of the Sierra Madre de Chiapas, approximately 100 km east of the *A. grandis* population. It is unknown whether the utilization of the same species of *Hampea* by the two weevils is the result of different habitat preferences or the result of a relatively recent displacement of *A. townsendi* by enormous populations of *A. grandis* developing on cultivated cotton in the coastal plain.

Derivation of name.—This species is named in honor of Charles Henry Tyler Townsend (1863–1944), the first entomologist to conduct scientific study of the boll weevil. Townsend studied the boll weevil under difficult conditions in South Texas in the late 1800's immediately after the first discovery of the pest in the United States (Townsend 1895). He also traveled widely in México and made extensive collections of insects there.

Anthonomus mallyi **Jones and Burke, New Species**

(Figs. 3, 4, 11, 12, 16, 20, 26)

Body elongate-oval; length 4.67–5.17 mm ($\bar{x}$ = 4.98, n = 7); width 2.17–2.42 mm ($\bar{x}$ = 2.32, n = 7). Integument shining, tan, head and rostrum brown (type series reared; specimens somewhat teneral; well hardened specimens expected to be darker). Vestiture sparse, consisting of fine, yellowish white, prostrate pubescence; shorter and irregularly distributed in patches on elytra (Figs. 3, 4); faint median vitta on pronotum; nowhere on body completely obscuring integument. *Rostrum* slightly curved in both sexes, that of female being nearly straight (Figs. 3, 4); rostrum of male 1.8× and that of female 2.5× longer than prothorax along dorsal midline; ratios of rostrum length past antennal insertion to width (measured in side view) 1.7 for male and 4.0 for female. Pubescence on rostrum of both sexes sparse, inconspicuous except near base, not extending distad of level of antennal insertions (Figs. 11, 12). Median and lateral carinae rounded, with intervening grooves shallow, not quite reaching level of antennal insertions. Lateral rostral groove relatively well defined; upper margin impinging against front margin eye at about middle. *Eyes* moderately strongly convex in dorsal view, not free behind; separated in front by distance equal to ca. ½ width of rostrum at base. *Frons* foveate; vestiture sparse, about same density as on pronotum. *Antennae* attached at ca. apical ¾ of rostrum in male and slightly distad of middle in female. Funicle 7-segmented; 1.5–1.8× longer than club; segment 1 slender, 2× length of segment 2, ca. as long as following four segments combined; remaining segments ca. equal in length. Club elongate, ca. as long as preceding six funicular segments combined; basal two segments loosely joined; apex sharply pointed. *Prothorax* with sides parallel in basal ½ then converging moderately strongly to subapical constriction; integument shining; elongate punctures smaller dorsally than laterally, each bearing an anteriorly pointing seta; areas between punctures bare, impunctate. Vestiture coalescing into faint to relatively well defined median vitta, laterally on pronotum uniformily distributed; scale-like setae on pleural region of prothorax striate (Fig. 20), stouter than those dorsally. *Scutellum* rectangular, parallel-sided, somewhat flattened dorsally, about 1.5× longer than wide; sparsely clothed with appressed, fine setae. *Elytra* in lateral view moderately strongly convex at base in dorsal ⅓ (Figs. 3, 4); distinctly wider at base than prothorax; humeri moderately strongly rounded; sides subparallel to point past middle then strongly rounded to apex. Basal margin from third interval outward relatively straight. Pubescence arranged in more-or-less regularly spaced patches on basal ½ of elytra, coalescing into more linear patterns towards elytral apex. Intervals somewhat flattened. *Ventral side* of body clothed with pubescence that does not completely obscure integument, finer and less dense on legs. Procoxae contiguous. Mesocoxae separated by distance equal to ca. ¼ width of coxa. Abdominal sternum 1 along midline equal in length to sterna 2 + 3. *Legs* moderately stout (Figs. 3, 4). Profemora 3.0–3.5× longer than wide; bearing two teeth; basal tooth slightly quadrate, 1.8–3.1× longer than broadly triangular distal tooth. Meso- and metafemora ca. equal in size, each bearing a small, sharply pointed tooth. Protibia relatively straight, moderately sinuate on inner margin. Meso- and metatibiae each slightly sinuate on inner margin. Tarsal claws each bearing a long tooth on inner margin, the apex or which reaches past the middle of claw. Median lobe of male strongly curved in lateral view, especially in distal ⅓, length of apex (distance from retracted phallotreme to apex of lobe) greater than width, apex strongly constricted (Fig. 26).

Type series.—Holotype ♂- EARTH School Reserve, Mpio: Pocora, Limón, Costa Rica, August 17, 1992, R. Jones and P. Krauter, Ex. *Hampea appendiculata.* Paratypes: 2 ♂s, 4 ♀s, same data as holotype.

The holotype and some paratypes are deposited in the Collection of the Department of Entomology. Texas A&M University. Paratypes are also deposited in the Museo Nacional de Costa Rica, San José, Costa Rica.

Diagnosis and variation.—The long, narrow rostrum of the female (Fig. 3) of *A. mallyi* is the most distinctive external character distinguishing this species from others in the group. The ratio of length of rostral apex (from antennal insertion to apex) to width (3.6–4.2) is significantly higher for females of *A. mallyi* than for the other species. The rostra of both the males and females of this species are the least densely hirsute of any members of the complex. Furthermore, the rostrum of the female is virtually devoid of distinguishable carinae (Fig. 12). The male median lobe is uniquely constricted at the apex (Fig. 26), readily distinguishing this species from all others with which it is likely to be confused.

There is little variation in the overall size of the seven specimens of the type series. All of these specimens were reared from flower buds of equal size under constant conditions in the laboratory which may account for the uniformity in size. The variation noted in the color of the integument is probably due to the teneral condition of the reared specimens.

Host plants.—Members of the type series were reared from the flower buds of *Hampea appendiculata.* Although populations of *H. appendiculata* were examined at elevations ranging from 100 to 1200 m, the weevils were only found on trees occurring at the lowest level in moderately disturbed forests of the Atlantic coastal plain of Costa Rica.

Derivation of name.—This species is named in honor of Frederick W. Mally (1868–1939), the first entomologist employed by the State of Texas to study the biology and control of the boll weevil.

Anthonomus palmeri Jones and Burke, NEW SPECIES

(Figs. 5, 6, 9, 10, 17, 21, 27)

Body oblong-oval; length 3.42–4.92 mm ($\bar{x}$ = 4.11, n = 30); width 1.67–2.17 mm ($\bar{x}$ = 1.90, n = 30). Integument of body shining, typically dark brown (some specimens of type series lighter in color due to teneral condition). Vestiture consisting of coarse, yellowish-white pubescence; scale-like setae somewhat broader and uniformly distributed on thorax, occasionally more densely concentrated on midline of pronotum; distributed in irregular patches on elytra (Figs. 5, 6). *Rostrum* moderately curved in both sexes; more strongly and evenly curved in female (Figs. 5, 6); male rostrum 1.7× and female 1.8× longer than prothorax along dorsal midline. Ratio of apical rostral length (from antennal insertion to apex) to rostrum diameter (in lateral view at level of antennal insertion) 1.6 for male and 2.6 for female. Pubescence on male rostrum variable in density, sometimes sparse, extending dorsally and laterally distad of antennal insertion, that of female extending to antennal insertion (Figs. 9, 10). Median and sublateral rostral carinae pronounced and extending to level of antennal insertion in both sexes. Lateral rostral groove well defined; dorsal margin impinging against eye at about middle. *Eyes* moderately convex in dorsal view, not free behind; separated in front by distance equal to ca. ⅗ width of rostrum at base. *Frons* deeply foveate; covered with fairly dense vestiture of fine, curved setae, not obscuring integument. Antennae attached at about apical ⅗ of rostrum in male and at slightly less than apical ¾ in female. Funicle 7-segmented; segment 1 slender, approximately equal in length to next three funicular segments combined. Antennal club with basal two segments rather loosely joined; anterior margins of club segments bearing large scales; apex sharply pointed; subequal in length to preceding six funicular segments combined. Prothorax with sides parallel to subparallel in basal ⅔ then converging to distinct subapical constriction; width of apex of prothorax ½ width of base; integument shining, bearing deep punctures that are smaller dorsally than laterally; areas between punctures smooth, bare. Vestiture uniformly distributed laterally, punctures each bearing a scale-like seta (Fig. 21), sometimes with slight concentration of setae above coxae (Fig. 17). *Scutellum* ca. 2× longer than wide, sides parallel to subparallel; sparsely to densely covered with fine, appressed setae, more densely clothed at apex. *Elytra* strongly convex dorsally in basal ⅓; distinctly wider at base than prothorax; humeri moderately strongly rounded; sides subparallel to point past middle then strongly rounded to apices; basal margin slightly sinuate due to expanded third elytral interval. Elytral pubescence arranged in square to irregularly shaped patches on basal half of elytra; coalescing into more linear patterns towards elytral apex. Intervals slightly convex. *Ventral side* of body sparsely to densely clothed with fine to coarse pubescence. Procoxae contiguous. Mesocoxae separated by distance equal to ca. ¼ width of coxa. Abdominal sternum 1 along midline slightly shorter than 2. Sternum 3 about ⅓ longer than 4. *Legs* moderately stout (Figs. 5, 6). Profemur 3.1–3.6× longer than broad; bearing two teeth, the basal one being acutely pointed and 1.5–2.5× longer than broadly triangular distal tooth. Meso- and metafemora about equal in size, each bearing a small, triangular tooth. Protibia relatively stout, moderately strongly curved in basal ⅓; inner margin fairly strongly sinuate. Meso- and metatibiae not as strongly sinuate on inner margins. Tarsal claws each bearing a long slender tooth, the apex of which reaches past middle of claw. *Median lobe* of male slightly curved in lateral view; apex broadly rounded, width equal to distance from retracted phallotreme to apex (Fig. 27).

Type series.—Holotype ♂- México: Chiapas, Tenejapa, below Paraje Yashanal, VII-3-1990, R. W. Jones and D. Baro, ex *Hampea longipes* (ground buds). Paratypes (55) as follows: Two ♂s with same data as holotype; 1 ♂, 1 ♀ with same label data as holotype except collected VII-4-1990; 2 ♂s with same label data as holotype except collected VII-25-1990; 1 ♂ with same label data as holotype except collected VI-26-1990; 1 ♂ with same label data as holotype except collected VII-14-1991 by R. W. Jones. One ♂, 2 ♀s-México, Paraje Yashanal, Tenejapa, VIII-8-1989, R. Jones, J. Cate, P. Krauter, ex. *Hampea longipes*. Two ♂s, 1 ♀-Mexico-nr. Paraje Yashanal, Tenejapa, VII-2-1991, R. W. Jones, ex *Hampea longipes* (ground buds). Four ♂s and 9 ♀s- México: nr. Laguna Cinco Lagos, Mpio. La Trinitaria, Chiapas, VII-4-1990, R. Jones and D. Baro, ex. *Hampea montebellensis* (ground buds); 1 ♂ and 1 ♀ with same data except collected VIII-2-1990; 1 ♀ with same label data except collected VIII-11-1990; 3 ♂s and 2 ♀s with same label data except collected VIII-21-1990. Nine ♂s and 11 ♀s- México: Lagunas de Montebello Natl. Park, VIII-9-1989, R. Jones, J. Cate, P. Krauter, ex. *Hampea montebellensis.*

The holotype and some paratypes are deposited in the Insect Collection of the Department of Entomology, Texas A&M University. Paratypes are also deposited in the collections of: Instituto de Biología, Universidad Autónoma de México, México, D. F.; El Colegio de la Frontera Sur, San Cristobal de las Casas, Chiapas, Mexico; Canadian Museum of Nature, Ottawa, Canada; and Charles W. O'Brien.

Diagnosis and variation.—*Anthonomus palmeri* is generally the smallest member of the *A. grandis* complex although there is considerable size variation in this group of species. The small size of *A. palmeri* generally distinguishes it from *A. townsendi* which it most closely resembles. *Anthonomus palmeri* also has a more strongly curved rostrum with the antennae of the female attached farther from the base of the rostrum. In addition, the profemur of *A. townsendi* is more robust than that of *A. palmeri* and the proximal tooth is usually much larger than the distal tooth. The less strongly curved median lobe with its broader apex distinguishes *A. palmeri* from *A. grandis, A. hunteri,* and *A. mallyi.* Furthermore, *A. palmeri* is separated from *A. grandis* by having the scales on the pleural region of the prothorax uniformly distributed as compared to the patterned arrangement of the latter. The rostrum of the female of *A. palmeri* (Fig. 5) is more hirsute and the dorsal carinae are more distinct than in *A. mallyi* or *A. hunteri* (Figs. 10, 12).

As is common in this species complex, the major variation in the type series of *A. palmeri* is in size. Specimens range from 3.42 to 4.92 mm in length. The diagnostic characters are retained throughout the series regardless of size. The greatest overall variation in size occurs between specimens of the two host plant populations (*H. montebellensis* and *H. longipes*). Specimens of *A. palmeri* from *H. longipes* are the smallest weevils in the *A. grandis* group. Specimens from *H. montebellensis* are larger, though still relatively small compared to other species in the complex. The dorsal pronotal vitta is absent on some individuals in the type series, most of which are from *H. longipes.* Scale patterns on the lateral margins of the prothorax vary slightly in uniformity of distribution. Some individuals have a distinct elliptical aggregation of scales above the procoxae as is found in *A. townsendi*; however, this aggregation is indistinct in other individuals. The color of the integument of the rostrum and prothorax varies from brown to almost black. Although there is some overlap in colors in specimens from the two hosts, weevils reared from *H. longipes* have the darkest integument while specimens reared from *H. montebellensis* are usually lighter in color.

Host plants.—The known hosts of *A. palmeri* are *H. longipes* in the Central Highlands of Chiapas, and *H. montebellensis* in the Lagunas de Montebello region of eastern Chiapas. These hosts occur above 1200 m in humid, relatively cool, montane forests.

Derivation of name.—This species is named in honor of Edward Palmer (1831–1911) who during his extensive natural history explorations of México was the first to report *A. grandis* as a pest of cotton. After having observed a cotton field heavily damaged by the boll weevil near Monclova in the state of Coahuila, México in 1880, he sent specimens to entomologists in Washington, D.C. His report alerted entomologists to the threat this weevil posed for cotton production.

DISCUSSION

As noted earlier, *A. townsendi, A mallyi,* and *A. palmeri* are close allies of *A. grandis.* In fact, they were initially considered to be conspecific with *A. grandis.* However, further analysis of their characters indicated that they are distinct from the three recognized forms of *A. grandis* as well as from each other. Morphological analysis of a large number of specimens of *A. grandis* from thoughout its geographic range and from its various hosts (Burke 1986, Burke et al. 1986) provided a basis for critical comparison of the newly discovered species with this highly variable and widely distributed species. The most obvious and consistent character separating *A. grandis* from the other species of the group is the clear demarcation of densely arranged, blunt scale-like setae on the ventral one-half of the pleural region of the prothorax as compared to those on the dorsal one-half. This character is present on specimens of *A. grandis* from all host and geographic populations. This, and the distinctive male median lobe, confirms that the variable populations on all hosts other than *Hampea* are *A. grandis*. The second line of evidence that the taxa of *Anthonomus* described herein are distinct species comes from the apparent reproductive isolation based on host and geographic differences. Although species of the *A. grandis* group are not known to occur in sympatry, large populations of *A. grandis* on cultivated cotton often occur fairly close to some of the species on *Hampea*. For example, *A. grandis* was observed to occur in large numbers in a small, isolated cotton field ca. 50 kms from collection sites of *A. townsendi* on *H. mexicana* in the Central Depression area of Chiapas. Given the proven flight capabilities and abundance of *A. grandis,* the probability of eventual sympatry occurring between this species and *A. townsendi* would appear to be high, especially since *H. latifolia* is known to serve as host for both species. However, no sympatry or evidence that the two species interbreed have been found.

The discovery of three undescribed species of *Anthonomus* on four of the nine species of *Hampea* examined in the field reveals some interesting information about the association of species of the complex with their *Hampea* hosts. The restriction of *A. townsendi, A. mallyi, A. palmeri,* and the previously described *A. hunteri* to *Hampea* as hosts, and the fact that species of this plant genus also serve as occasional hosts of *A. grandis,* strongly supports the conclusion of Burke et al. (1986) that *Hampea* is the ancestral host genus of the entire group. Since *Hampea* and members of the *A. grandis* group have apparently had a long association, the possibility is great that other undescribed species of related weevils remain to be discovered on the remaining eight species of *Hampea* not examined during this and previous studies. However, the fact that weevils of this group were not found on five species of *Hampea* examined in the field indicates that ecological, morphological, historical, and/or chemical factors may be involved in preventing infestations. Further field and taxonomic studies of both the *A. grandis* species complex and the genus *Hampea* may elucidate the factors involved and nature of the evolutionary processes in this insect/plant association. There is considerable urgency in conducting such studies since some species of *Hampea,* and possibly their associated weevils, may have recently been extirpated and others are clearly threatened.

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A NEW SUBGENUS AND SPECIES OF THE GENUS *BRACHYUNGUIS* DAS (HEMIPTERA: APHIDIDAE) FROM ARGENTINA

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Abstract.—***Brachyunguis (Andinaphis) paradoxus,*** new Argentinean subgenus and species are described. The new subgenus and new species are characterized by the absence of marginal papillae, processus terminalis of the antennal segment VI longer than the base of segment, tarsal formula 3.3.3 and its host-plant, *Senecio* (Asteraceae). These characters are very atypical among *Brachyunguis* and even Aphidini. Apterous and alate viviparous females and oviparous females are described. The subgenus and species are keyed in two modified previous keys.

Key Words: aphid, *Brachyunguis, Andinaphis,* new subgenus, new species, *Senecio,* Argentina

Resumen.—"Nuevos subgénero y especie del género *Brachyunguis* Das (Hemiptera Aphididae) de Argentina". Se describen las hembras vivíparas ápteras y aladas y las oviparas de ***Brachyunguis (Andinaphis) paradoxus*** n. subgen., n. sp., a partir de material recogido sobre *Senecio subumbellatus* (Asteraceae) en la provincia de Mendoza (Argentina). La completa ausencia de papilas marginales en el protórax y en el abdomen (carácter atípico en *Brachyunguis* y muy infrecuente en Aphidini), la longitud del filamento terminal del VI artejo antenal: más largo que la base del mismo, la fórmula tarsal: 3.3.3, y la planta hospedadora, caracterizan tanto el subgénero como la especie. Ambos nuevos taxones se incluyen en conocidas claves anteriores, que se modifican convenientemente.

Palabras clave: pulgón, *Brachyunguis, Andinaphis,* subgénero nuevo, especie nueva, *Senecio,* Argentina

Two species of *Brachyunguis* Das, 1918 are known in South America: *B. (Xerophilaphis) blanchardi* Remaudière and Bahamondes, 1987, and *B. (B.) bahamondesi* Remaudière and Halbert, 1996. Both were described recently from Mendoza province, Argentina, and live on Chenopodiaceae, on *Allenrolfea vaginata* and on *Atriplex lampa* plus *Chenopodium sooanum,* respectively.

In North America (Remaudière and Halbert 1996) three other species of the genus are known, all of them on Chenopodiaceae: *B. (B.) bonnevillensis* (Knowlton, 1928) on *Atriplex* and *Sarcobatus, B. (X.) tetrapteralis* (Cockerell, 1902) on *Atriplex* and *Suaeda,* and *B (B.) bishopi* Remaudière and Halbert, 1996 on *Sarcobatus.*

The plant hosts of the *Brachyunguis* species of the Old World are Chenopodiaceae (mainly), Tamaricaceae, Asclepiadaceae, Zygophyllaceae and Sapindaceae, never Asteraceae.

The genus *Brachyunguis* is included in the subtribe Aphidina. Marginal papillae are present normally on the prothorax and abdominal segments I and VII, and frequently also on abdominal segments II to VI in this subtribe. However, there are some exceptions (Eastop 1979): *Cryptosiphum* Buckton, 1879 (on *Artemisia,* Asteraceae, palearctic), *Indiaphis* Basu, 1969 (on *Rhododendron,* Ericaceae, oriental) but this genus may be included in Macrosiphini (Remaudière and Remaudière 1997), *Misturaphis* Robinson, 1967 (on *Artemisia,* Asteraceae, nearctic), *Polytrichaphis* Miyazaki, 1971 (on *Illicium,* Illiciaceae, palearctic from Japan, also included in Macrosiphini by Remaudière and Remaudière 1997) and *Sanbornia* Baker, 1920 (on *Juniperus,* Cupressaceae, nearctic).

Brachyunguis is divided in two subgenera *Brachyunguis* s. str. (present in Asia, Europe, North [Mediterranean] Africa and America, and *Xerophilaphis* Nevsky, 1928 (Asia and America). Also from Mendoza province (Argentina), the second author found some aphids which can be ascribed to the genus *Brachyunguis.* However, they belong to a new subgenus, *Andinaphis,* characterized by the absence of marginal papillae (an atypical characteristic in Aphidini) and three atypical characteristics among *Brachyunguis:* a) processus terminalis of the antennal segment VI longer than the base of segment, b) tarsal formula 3.3.3, and c) unusual host-plant, *Senecio* (Asteraceae).

Abbreviations used in the text are as follows: ant.III, IV, V = antennal segments III, IV, V; ant.VIb = base of antennal segment VI; ant.VIpt = processus terminalis of antennal segment VI; b.d.III = basal diameter of antennal segment III; BL = body length; h.t.II = second segment of hind tarsus; u.r.s. = ultimate rostral segment.

Andinaphis Mier Durante, Ortego, and Nieto Nafría, NEW SUBGENUS

Type species.—*Brachyunguis (Andinaphis) paradoxus* n. sp.

Etymology.—The name *Andinaphis* is taken from the Neo-Latin words "andinus" and "aphis", Andean and aphid, respectively. The gender is feminine as *Aphis.*

Description.—Light green or yellow when alive, poorly pigmented, without segmental sclerites on abdomen. Frontal profile convex, antennae shorter than body length, processus terminalis of antennal segment VI longer than 1.3 times base of this segment, secondary rhinaria normally present on antennal segment III of apterous viviparous females and on antennal segments III and IV of alatae, also sometimes present on III on oviparous females, tarsal formula 3.3.3 with exceptions (2 setae on front and middle legs), siphunculi truncated-cone shape and shorter and darker than cauda, which is more or less long triangular or fingerlike with 8 setae at most, without marginal papillae on prothorax and abdominal segments, including I and VII. Monecious holocyclic on *Senecio* (Asteraceae), on aerial parts of the plants.

Discussion.—*Andinaphis* can be distinguished from other subgenera of *Brachyunguis (Brachyunguis* s. str. and *Xerophilaphis*) by: 1, the total absence of marginal papillae (marginal papillae are present on prothorax and abdominal segments I and VII in both other subgenera); 2, the processus terminalis of VI antennal segment is 1.3–1.9 times as longer as base of the segment (this ratio is normally smaller in other subgenera); 3, the tarsal formula is 3(2).3(2).3, in the other subgenera it is 2.2.2 or 2(3).2(3).2; and 4, Asteraceae, not Chenopodiaceae, is the host-plant.

Andinaphis can not be confused with *Protaphis* (subgenus of *Aphis*) which also lives on Asteraceae and has small processus terminalis (0.9–1.5× base), because of five important characters (see the respective characters on *Andinaphis* in the description). *Protaphis* has mainly tarsal formula 3.3.2, is dark brown to black alive with black or very dark cauda, has some segmental sclerites on abdomen of apterous females, has 7–16 caudal setae, and often lives on the subterranean parts of the plants.

The subgenus can be identified by modifying Eastop's (1979) key as follows.

1–4. [without modification]

5. Lateral tubercles [papillae] absent from both first and seventh and usually also the other abdominal segments. Processus terminalis 1.3–5.5 times as long as the base of the sixth antennal segment 6

– Lateral tubercles present on the first and usually also on the seventh abdominal segments 8

6. Triommatidion inconspicuous. Siphunculi wider than and about 2½ times as long as the cauda. On *Rhododendron* (Ericaceae), India [in Macrosiphini, by Remaudière and Remaudière 1997] . . . . *Indiaphis*

– Triommatidion evident at hind margin of eye 6b

6b. All first tarsal segments bearing only 2 hairs. Processus terminalis 3.0–5.5 times as long as the base of antennal VI 7

– Normally first tarsal segments bearing 3 hairs, sometimes some tarsus of the front and medium legs with 2 hairs. Processus terminalis 1.3–1.9 times as long as the base of antennal VI. On *Senecio* (Asteraceae), South America . . . . *Brachyunguis (Andinaphis)*

7. (and the following disjunctives) [without variation]

Brachyunguis (Andinaphis) paradoxus Mier Durante, Ortego, and Nieto Nafría, New Species

(Figs. 1, 2)

Apterous viviparous female (n = 192; 31 measured) (Figs. 1, 2).—Body 1.11 to 2 mm long. Light green when alive, exceptionally yellow greenish, with white waxy powder; pale specimens with only tarsi, knees, apex of siphunculi and ultimate rostral segment light brown and more pigmented specimens with a part of femora, knees, apex of tibiae, tarsi, ultimate rostral segment, siphunculi and anal plate brown and cauda light brown. Prepared specimens light yellow in general with head, distal rostral segments, legs (apex of tibiae and tarsi browner), siphunculi, cauda and genital and anal plates more or less light brown and intersegmental (sometimes inconspicuous) and stigmatic sclerites smoky.

Cuticle more or less smooth. Setae (table 1) pale and acute in general. Without papillae on prothorax and abdominal segments I and VII. Frontal profile convex. Setae on vertex usually shorter than b.d.III and longer than antennal setae. Clypeus more or less as wide as interantennal space but never exceeding front. Antenna 6 segmented, (0.58)0.7 to 1.03 mm long, 0.45 to 0.67 times body length (BL); ant.III with (0)1–6(8) widely irregular and flanged secondary rhinaria; antennal segment lengths (in mm): ant.III = (0.13)0.16 to 0.29; ant.IV = (0.09)0.11 to 0.19; ant.V = 0.09 to 0.18; ant.VIb = 0.07 to 0.10; ant.VIpt = (0.10)0.12 to 0.17; ant.III 1.20 to 2.13 times longer than ant.VIpt, which is 1.33 to 1.88 times longer than ant.VIb; antennal setae few (2 to 6 on ant.III and 1 to 3 on ant.VI.b) and short. Rostrum (0.38 to 0.47 mm long) reaching third coxa; BL 2.54 to 4.65 times length of rostrum; u.r.s pointed, with sides straight or slightly concave, 0.08 to 0.11 mm long, 1.54 to 2.11 times as long as its basal width, 0.70 to 0.80(0.95) longer than h.t.II, 0.90 to 1.12 times ant.VIb., with 2 accessory lateral setae. Posterior seta on trochanter of hind leg shorter than the basal diameter of femur; dorsal and ventral setae on femora few (2 to 6 ventral ones) and short; hind tibia 0.34 to 0.55 times BL; first tarsal segments with 3.3.3 setae, exceptionally 2 setae on meso- and meta-thoracic legs; h.t.II 0.10 to 0.14 mm long, 0.15 to 0.25 times hind tibia. Abdominal setae short; presiphuncular abdominal segments with 2 marginal setae each side and normally with 2 spinal setae; abdominal segment VIII with 2 setae, exceptionally 4, longer than anterior ones. Siphunculi truncated-cone shape, 0.05 to 0.10 mm long, 0.95 to 1.54(1.73) times its basal width and

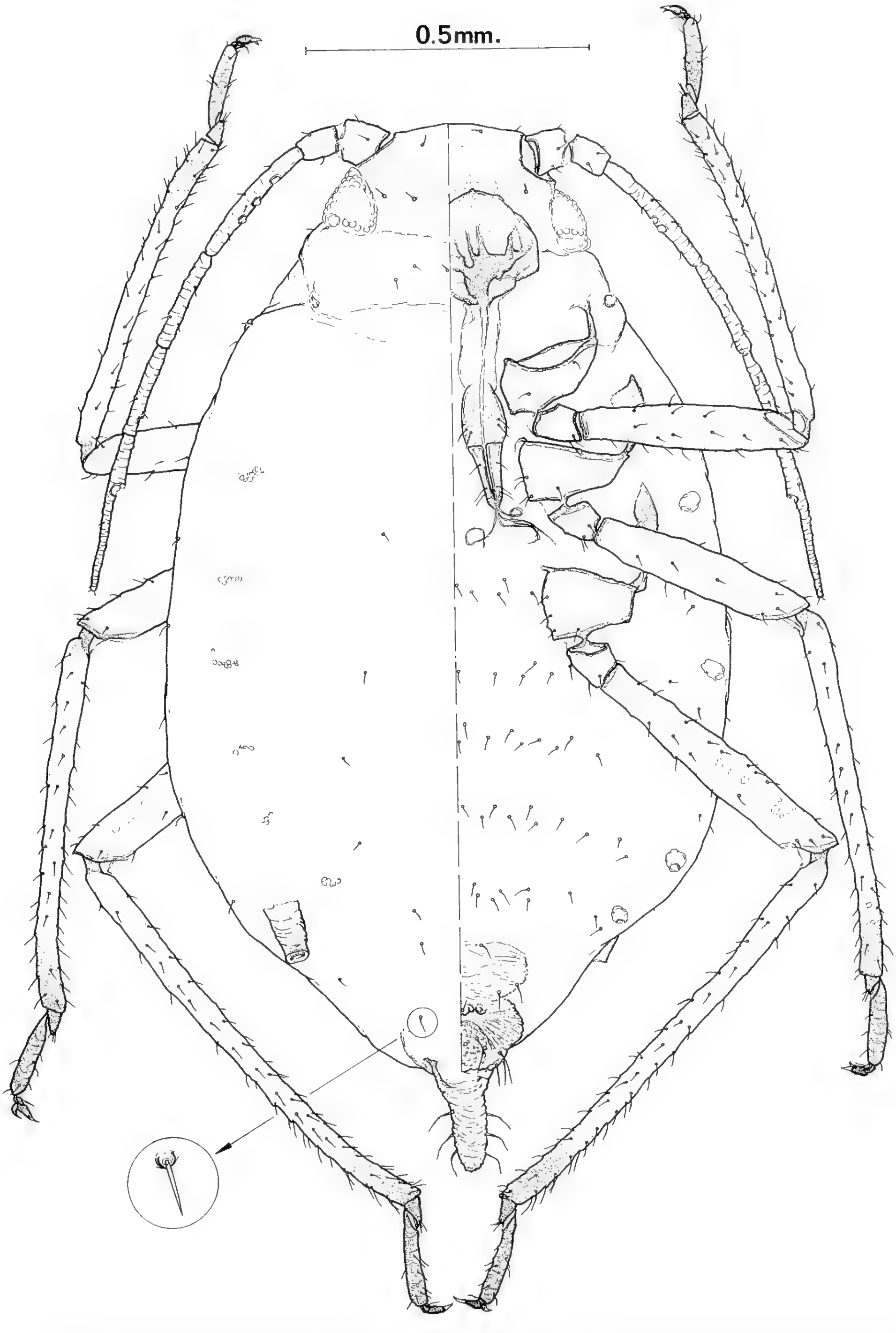

Fig. 1. *Brachyunguis (Andinaphis) paradoxus,* habitus. Illustration by M. Enrique Ortega Lorenzo (León, Spain).

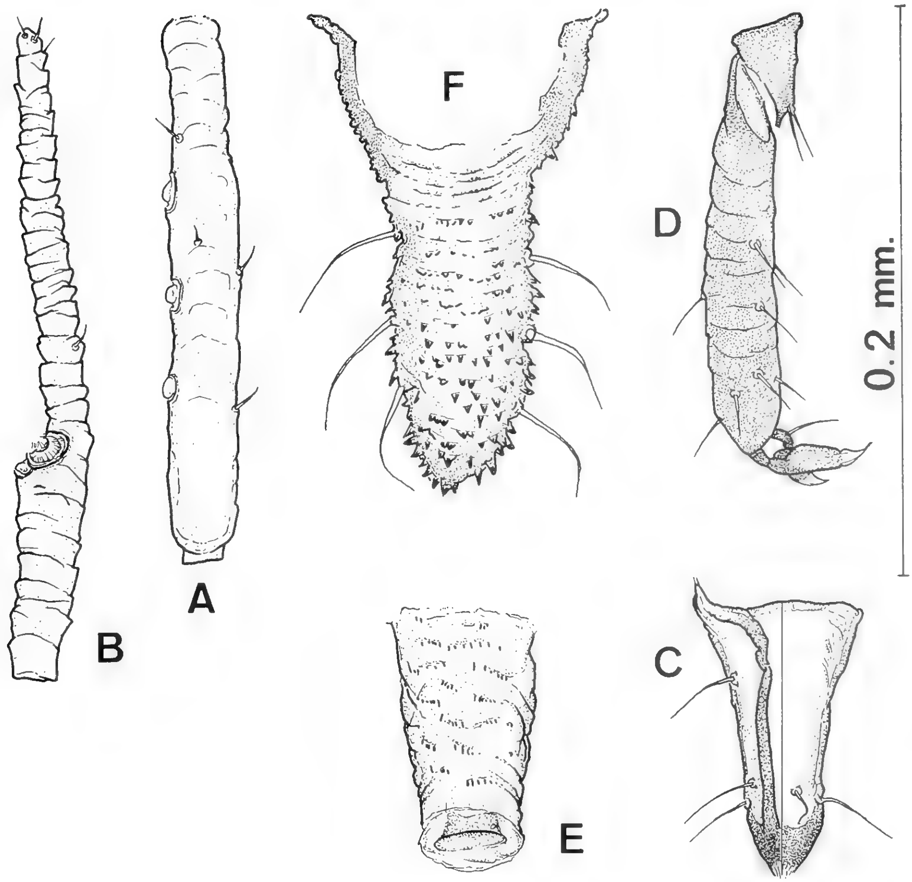

Fig. 2. *Brachyunguis (Andinaphis) paradoxus.* A, III antennal segment. B, VI antennal segment. C, Ultimate rostral segment. D, Hind tarsus. E, Siphunculus. F, Cauda. Illustrations by M. Enrique Ortega Lorenzo (León, Spain).

Table 1. Measurements of setae of *Brachyunguis (Andinaphis) paradoxus.* Abbreviations: D = diameter of trochanter-femoral joint; abd. seg. = abdominal segment; other abbreviations as in text.

		ap. viv. fem	al. viv. fem.	ovip. fem.
ant. III	µm long	7–13	10–13	7–10
	b.d. III times	0.4–0.8	0.6–1.0	0.4–0.7
Vertex	µm long	10–18	10–20	11–14
	b.d. III times	0.6–1.3	(0.8)1.0–1.6	0.7–1.0
Hind trochanter	µm long	20–30	22–30	22–33
	D times	0.5–0.8	0.5–0.7	0.5–0.8
Dorsal hind femur	µm long	5–18	12–23	7–18
	b.d. III times	0.4–1.3	(0.7)1.0–1.8	0.4–1.2
Ventral hind femur	µm long	12–25	17–28	18–24
	b.d. III times	0.7–1.8	1.3–2.0	1.0–1.6
abd. seg. III: spinal	µm long	10–14	10–18	11–15
abd. seg. III: marginal	µm long	10–18	12–20	8–15
	b.d. III times	0.6–1.1	0.6–1.5	(0.4)0.6–1.0
abd. seg. VIII	µm long	12–25	15–28	15–23
	b.d. III times	0.9–1.6	1.0–2.0	1.0–1.7

0.33 to 0.52(0.62) times the cauda; subgenital plate with 2(4) anterior, 0(2) discal and 5–10 posterior setae; cauda fingerlike, (0.10)0.13 to 0.20 mm long, 1.40–1.78 longer than its basal width, with 5 to 7 lateral and exceptionally 1 dorsal setae.

Alate viviparous female (n = 38; 24 measured).—Body (1.12)1.52–1.89 mm long. Alive and mounted similar to the apterae, but darker on head, antenna (some times the basal art of ant.III), thorax and legs. Metric and meristic characters very similar to aptera, but with following differences. Antenna = 0.80–1.06 mm, 0.51–0.68 times BL; secondary rhinaria: 4–9 on ant.III and 0(most frequent)–2 on ant.IV; antennal segment lengths (in mm): ant.III = 0.21–0.31, ant.IV = 0.17–0.22, ant.V = 0.12–0.24, ant.VIb = 0.8–0.12; ant.VIpt = 0.13–0.18; ant.III 1.33–1.94 times ant.VIpt.; u.r.s. 0.82–1.05 times ant.VIb; u.r.s. 0.64–0.85 times h.t.II; siphunculus 1.16–2 times its basal width; subgenital plate with 2–5 anterior, 0–2 discal and 6–9 posterior setae; cauda 1.17–1.70 times its basal width. Setae (Table 1) similar to those in apterae.

Oviparous female (n = 35; 14 measured).—Body 1.4 to 1.8 mm long. Very similar to viviparous female, with metathoracic tibiae enlarged with (40)60 to 110 scent plates. But some characters slightly different: hind tibia 0.28–0.40 times BL; antenna (0.64–0.95 mm long) 0.41–0.67 times BL; ant.III and ant.IV secondary rhinaria 0–1(4) and 0, respectively; ant.III 1.06 to 1.74 times ant.VIpt; u.r.s. 0.67–0.9 times h.t.II; 4 to 10 setae on abdominal tergite VIII; subgenital plate with 11–28 anterior and discal (mixed) and 10–16 posterior setae; cauda 1.05–1.67 longer than its basal width with 4–8 lateral setae. Setae (Table 1) as in apterae ones.

Eggs measured in the females: 0.7 × 0.4 mm.

Male.—Unknown.

Type material.—Holotype: apterous viviparous female (measured specimen number 1) collected on *Senecio subumbellatus* Phil. at Malargüe "Arroyo El Rezago" (Mendoza province, Argentine), 8-III-96, J. Ortego leg., in collection Universidad de León (Departamento de Biología Animal). Paratypes: apterous, alate viviparous and oviparous females found (J. Ortego leg.) on the same host-plant at the same locality, 8-III-96 and 7-IV-96 and on the same host-plant at Malargüe "Refugio del Club Andino", 15-V-94, deposited in the authors' collections and in The Natural History Museum, London, Muséum National d'Histoire Naturelle, Paris, and S. Halbert collection, Gainesville, Florida (USA).

Etymology.—The specific name is taken of classic Greek: παραδοξοσ, paradoxical, surprising, because the peculiar characters of the species (see discussion of the new subgenus).

Biology and distribution.—*Brachyunguis (Andinaphis) paradoxus* is monoecious holocyclic on *Senecio subumbellatus* and perhaps on other Andean *Senecio* spp. It forms small and dense colonies on the aerial part of the plant, mainly on the floral stems. It is very possible that this new species is restricted in distribution to the Andes Range in Argentinian provinces of Mendoza (Malargüe: "Arroyo El Rezago", 1905 m, "Refugio del Club Andino", 2225 m and "El Carrizalito", 2025 m) and Neuquen plus adjacent localities of Chili, as is its plant-host.

Discussion.—*Brachyunguis (Andinaphis) paradoxus* is the only known species of the subgenus. The key established by Remaudière and Halbert (1996) to the American species of *Brachyunguis* can be modified to include the new species as following form:

1. [without variation]; subgenus *Xerophilaphis* 2
– [without variation] 2b
2. [without variation, to *B. (X.) tetrapteralis* and *B. (X.) blanchardi*]
2b. Marginal papillae absent on prothorax and abdomen. Ant.VIpt 1.33 times ant.VIb at least and normally more than 1.4; u.r.s. shorter than h.t.II. On *Senecio*. Argentina; subgenus *Andinaphis:* . . . . . *B. (A.) paradoxus*
– Marginal papillae present on prothorax and

abdominal segments I and VII. Ant.VIpt 1.30 times ant.VIb normally, if 1.4 times, u.r.s. longer than h.t.II. Not on *Senecio*; *Brachyunguis* s. str. 3

3–6. [without variation, to *B. (B.) bishopi* and *B. (B.) bonnevillensis*]

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ANATOMY OF THE REPRODUCTIVE SYSTEM IN SIX *ANASTREPHA* SPECIES AND COMMENTS REGARDING THEIR TERMINOLOGY IN TEPHRITIDAE (DIPTERA)

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Abstract.—A comparative study of the anatomy of the reproductive system of mature males and females of the following species was performed: *A. serpentina* (Wiedemann), *A striata* Schiner, *A cordata* Aldrich, *A. ludens* (Loew), *A. obliqua* (Macquart) and *A. fraterculus* (Wiedemann). The study material came from diverse regions of the states of Veracruz and Chiapas, Mexico. In females, several important differences among species were observed: in the number of ovarioles, morphology of the ventral receptacle, *signum,* spermathecae and aculeus. In males, differences were apparent in the accessory glands, ejaculatory apodeme of the sperm pump, distiphallus and surstyli. For the first time, the real location of the seminal vesicles is shown and the aedeagal gland is described. A comparative discussion ensues regarding terminology and the location of various structures in both sexes.

Key Words: *Anastrepha,* reproductive system, females, males, anatomy

The genus *Anastrepha* includes 185 species occurring only in the Western Hemisphere. Despite the great diversity and wide distribution of this genus, most studies have concentrated exclusively on a few species of economic importance (Hernández-Ortiz and Aluja 1993).

Williamson's (1989) review and synthesis of studies of the descriptive anatomy of the reproductive system, oogenesis and spermatogenesis was limited to only a few fruit fly species. Studies of females of the following species have been published: *Rhagoletis pomonella* (Walsh) (Dean 1935), *Ceratitis capitata* (Wiedemann) (Hanna 1938, Valdéz Carrasco and Prado Beltrán 1990), *Xanthaciura unipuncta* Malloch (Souza Lopes 1939), *Bactrocera tryoni* (Froggatt) (formerly *Strumeta*) (Drew 1969), *Bactrocera oleae* Gmelin (formerly *Dacus*) (Solinas and Nuzzaci 1984), as well as *Rhagoletis nova* (Schiner) and *R. conversa* (Brethes) (Flores et al. 1987).

For *Anastrepha* there is only general information regarding the anatomy of the reproductive system in females for *A. ludens* (Loew) (Dampf 1933, Servín-Villegas and Jiménez-Jiménez 1995), for *A. suspensa* (Loew) (Dodson 1978) and for *A. serpentina* (Wiedemann) (Martínez et al. 1995).

With respect to males, the information presently available consists of studies in *C. capitata* (Hanna 1938, Anwar et al., 1971), *X. unipuncta* (Souza Lopes 1939) and *B. tryoni* (Drew 1969). The studies of *Anastrepha* include species such as the following: *A. suspensa* (Dodson 1978), *A. serpentina* (Martínez et al. 1995), *A. ludens* (Servín-Villegas and Jiménez-Jiménez 1995) and several unidentified *Anastrepha* species (Bressan 1995).

A review of the aforementioned literature shows that much of the terminology used for Tephritidae by these authors differs substantially, regarding names and locations of certain structures.

In this paper we present a comparative study of the anatomy of the reproductive system for males and females of the following species: *A. serpentina* (Wiedemann), *A. striata* Schiner, *A. cordata* Aldrich, *A. ludens* (Loew), *A. obliqua* (Macquart) and *A. fraterculus* (Wiedemann). Furthermore, terminology and the location of certain structures such as the seminal vesicles and the aedeagal gland in males, and the *bursa copulatrix* and the ventral receptacle in females are discussed.

MATERIAL AND METHODS

Males and females of six *Anastrepha* species were obtained from larvae infesting their natural host plants from the following regions: *A. serpentina* from Región del Soconusco, Chiapas reared in *Pouteria sapota* (Sapotaceae); *A. striata* and *A. fraterculus* from the "Estación de Biología Tropical Los Tuxtlas", Veracruz reared in *Psidium guajava* (Myrtaceae); *A. cordata* from the "Estación de Biología Tropical Los Tuxtlas", reared in *Tabernaemontana alba* (Apocynaceae); *A. ludens* from Martínez de la Torre, Veracruz, reared in *Citrus sinensis* (Rutaceae); and *A. obliqua* from Apazapan, Veracruz, reared in *Spondias purpurea* (Anacardiaceae).

The emergence and development of adults took place under laboratory conditions; until the gonads reached full maturity, hydrolized protein (ICN-Biomedial Inc.) was provided as a food source. Approximately 50 individuals of each species and sex were analyzed (except *A. cordata,* for which only 7 specimens were observed).

Dissection of the individuals was performed under a stereomicroscope. Each specimen was placed in a petri dish in Ringer's solution. The reproductive systems were drawn while in this solution using a camera lucida. Specimens were fixed on slides in Carnoy's solution, then dehydrated, cleared and stained using the Feulgen light green technique. Finally, they were mounted whole in Canada Balsam (Gabe 1968).

In order to observe particular morphological structures such as the cuticular intima of the vaginal duct, ventral receptacle, spermathecae, and the aculeus in females, as well as the vas deferens, accessory glands and sperm pump in males, some reproductive systems were dissected in NaOH solution (4%) and stained with chlorazol black E following the technique described by Carayon (1969). Later they were dehydrated, cleared and mounted in Canada Balsam.

The terminalia of both sexes were prepared by cutting open the entire abdomen in NaOH (10%) solution which was boiled for a few minutes in order to remove all extraneous materials; the terminalia were later analyzed with a compound microscope. Microphotographs were made with a Zeiss photomicroscope.

RESULTS

Female Reproductive System

The general terminology employed here to describe females is based on the works of McAlpine (1981) and Norrbom and Kim (1988), and for particular internal structures we following Dean (1935). There is considerable terminological confusion among later studies that used different anatomical terms for the same structure or used incorrect terminology (Table 1).

The female *Anastrepha* reproductive system is made up of the following structures: two ovaries, two lateral oviducts, the common oviduct, two accessory glands, three spermathecae with their respective ducts, vagina and aculeus (Fig. 1A).

Even in mature females, the ovary is covered by a thin wall. The ovarioles (Fig.

Table 1. Comparison of some terminology used for the female reproductive system in Tephritidae.

Present Study	Dampf (1933)	Dean (1935)	Hanna (1938)	Drew (1969)	Solinas & Nuzzaci (1984)	Williamson (1989)
Ovary	ovary	ovary	ovary	ovary	ovary	ovary
Lateral oviduct	not indicated	lateral oviduct	oviduct	lateral oviduct	lateral oviduct	lateral oviduct
Common oviduct	not indicated	median oviduct	common oviduct	not indicated	common oviduct	common oviduct
Accessory glands	accessory glands	accessory glands	colleterial glands	colleterial glands	accessory glands	accessory glands
Spermathecae	spermathecae	spermathecae	spermathecae	spermathecae	receptaculum seminis	spermathecae
Bursa copulatrix	not indicated	*bursa copulatrix*	vagina	vagina	anterior vagina	*bursa copulatrix*
Ventral receptacle	not indicated	ventral receptacle	vagina	morula gland	fertilization chamber	ventral receptacle
Vaginal duct	oviduct	vagina	vaginal duct	vaginal duct	posterior vagina	vaginal duct
Cloacal opening	end oviduct	cloaca	genital opening	gonopore	not indicated	vulva

1B) are of the polytrophic type and have a terminal filament, germarium, vitellarium and calyx. The germarium contains the oögonial cells, nutritive cells and prefollicular cells. The follicles found in the vitellarium show varying degrees of maturity; each one is formed by 16 cells of germinal origin corresponding to one oocyte and 15 nutritive cells which are contained in the cavity defined by the follicular epithelium. The calyx, which opens into its respective lateral oviduct, is a prolongation of the vitellarium. The lateral oviducts are short and their walls very thin, both open into the common oviduct, which is slightly longer and reaches the anterior part of the vagina.

The vagina has two regions with different characteristics. The anterior part is modified to form a differentiated region of distinctive structure called the *bursa copulatrix*. The posterior part or vaginal duct is a long tubular duct which folds up before penetrating the aculeus. Parallel to the rectum, it flows into the cloaca.

The *bursa copulatrix* can be observed externally due to the greater thickness of its wall and because both the spermathecal and accessory gland ducts open into its dorsal side. The thickness of the *bursa copulatrix* is partly due to the presence of the ventral receptacle, a flatttened, sac-like structure protruding cephalad from its ventral side. The ventral receptacle has thick, highly ornamented cuticular walls.

The vaginal duct is long and tubular and it has a number of longitudinal pleats. At the end of its basal third, positioned dorsally, are two cuticular pieces called the *signum.*

Both accessory glands are oval in shape, voluminous and opaque. Each gland has a bulky base and extends into a thin, long duct which opens into the anterior part of the vagina.

The spermathecae are each made up of a sclerotized capsule surrounded by a secretory epithelium connected by a very long and thin spermathecal duct. All ducts open into the dorsal side of the *bursa copulatrix.*

The aculeus is a highly sclerotized structure; its morphology and length differ among species of *Anastrepha,* making it extremely important for the taxonomy of the genus.

In the studied *Anastrepha* species, the female reproductive system varies mainly in the number of ovarioles and in the morphological characteristics of the ventral receptacle, as well as in the *signum,* spermathecae and aculeus.

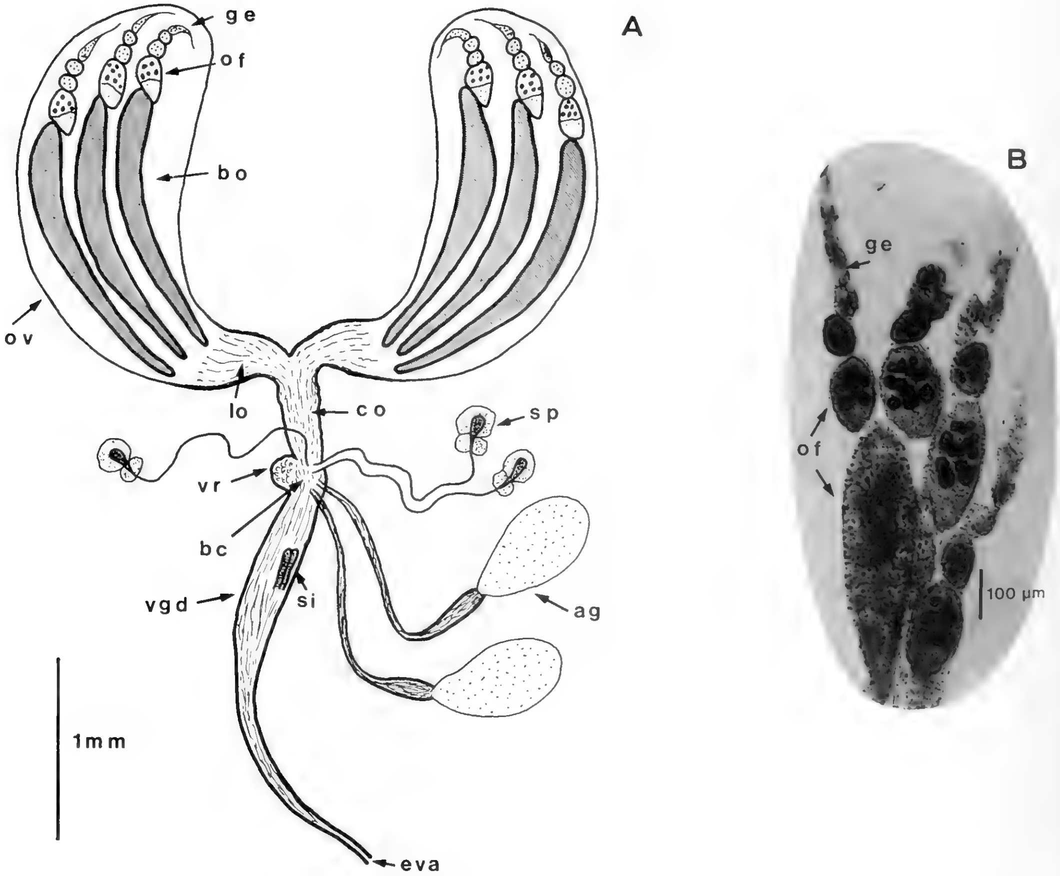

Fig. 1. Reproductive system of the female of *Anastrepha serpentina*. A, General morphology of the reproductive system. B, Microphotograph of the apical end of some ovarioles. Abbreviations: ag = accessory gland; bc = *bursa copulatrix*; bo = basal mature oocyte; co = common oviduct; eva = entrance of the vagina to aculeus; ge = germarium; lo = lateral oviduct; of = ovarian follicles in the vitellarium; ov = ovary (with some ovarioles figured); si = signum; sp = spermatheca; vgd = vaginal duct; vr = ventral receptacle.

The number of ovarioles present in the six species varied between 20 and 33 ovarioles per ovary. The highest average was observed in *A. obliqua* (30–33), *A. serpentina* (25–30) and *A. cordata* (25–28); the lowest averages were in *A. fraterculus* (20–24), *A. striata* (20–25) and *A. ludens* (22–25) (Table 2).

The ventral receptacle is usually elongated with numerous lobular papillae on its surface (Fig. 2A,B,D,E,F) except in *A. cordata,* in which it is almost spherical, shorter and almost completely without papillae (Fig. 2C; Table 2).

The *signum* is formed by two sclerotized plates which are long and sclerotized in *A. serpentina* and *A. striata* (Fig. 2A', B'), short and less sclerotized in *A. ludens* (Fig. 2D',E'), very short and more or less sclerotized in *A. fraterculus* (Fig. 2F') and inconspicuous in *A. cordata* (Fig. 2C').

The glandular units of the spermathecal secretory epithelium differ among species (Fig. 3). The spermathecal capsules are spherical in shape and usually covered by numerous sclerotized spiculae. The spermathecae of *A. ludens* tend to be longer than those of other species. In *A. cordata,* in contrast, the spermathecae are rounded and the spiculae are lacking. In *A. frater-*

Table 2. Some comparative characteristics in females of the *Anastrepha* species examined during this study.

Species	Number Ovarioles	Ventral Receptacle	*signum*
A. serpentina	25–30	elongated	2 plates
A. striata	20–25	elongated	2 plates
A. cordata	25–28	short	inconspicuous
A. ludens	22–25	elongated	2 plates
A. obliqua	30–33	elongated	2 plates
A. fraterculus	20–24	elongated	2 plates

culus the spermathecae are not consistently rounded, as they are in *A.obliqua* (Fig. 4 A–F).

The aculeus is usually sclerotized and dorsoventrally compressed. In *A. serpentina* it measures from 2.9–3.3 mm long; the tip (Fig. 4A') has tiny teeth which occupy the apical third. In *A. striata,* the aculeus is notably robust, measuring 2.1–2.3 mm long; its tip (Fig.4B') is broad with a marked constriction after the cloacal opening. The aculeus of *A. cordata* is very thin (less than 0.09 mm wide) and measures 4.7–5.5 mm long; the tip is short and lacks teeth laterally (Fig. 4C').

In species belonging to the *fraterculus* group, differences were observed in the length of aculeus tip and shape of its teeth. The aculeus of *A. ludens* varies in length from 3.2–5.0 mm and has scant broad, rounded teeth which occupy less than the apical half. In *A. fraterculus* it measures from 1.6–1.8 mm and has large, rounded teeth occupying half of the apical end; while in *A. obliqua* it measures from 1.4–1.7 mm and has large, sharp teeth which occupy three-fourths of the apical end (Figs. 4 D'–E'–F').

Male Reproductive System

The general terminology used to describe the male reproductive system is based on the works of Matzuda (1976) and McAlpine (1981), whereas for particular internal structures we followed Hanna (1938). We have also included a comparative synopsis of the terms employed for *Anastrepha* by some other authors (Table 3).

The male reproductive system is made up of two testes, two vas deferens, an ejaculatory duct, two seminal vesicles, several pairs of accessory glands, a sperm pump, an aedeagal gland and the aedeagus itself (Fig. 5).

The testes are oval-shaped and intensely bright yellow. In the apical part of each testis there is a germarium followed by regions of primary spermatocytes, secondary spermatocytes, spermatids, and sperm bundles, beyond which lies the basal region which, in mature males, contains a large quantity of free spermatozoids (Fig. 6A). Each testis opens into a vas deferens characterized by a very broad anterior part which thins out further on, finally opening into the anterior part of the ejaculatory duct.

In the ejaculatory duct, which is very long, three regions can be distinguished: the widest, the anterior region, into which two vas deferens, two seminal vesicles, and various pairs of accessory glands open; the intermediate region, which has a smaller diameter than the first and which, extremely thin at the end, runs through the base of the sperm pump; and the posterior region, which begins beyond the sperm pump and has a smaller diameter than the former two regions. Most of the last region is covered by a thick pleated wall, which makes its diameter look bigger; however, the external wall disappears distally immediately before reaching the basiphallus. At precisely this point, it connects to the aedeagal gland.

The accessory glands are paired, long and translucid; their wall is slightly thicker than the seminal vesicles.

There are two elongated seminal vesicles with thin walls; free spermatozoids, apparently immersed in a secretion, are visible in their interior. The vesicles open into the anterior part of the ejaculatory duct parallel to the vas deferens (Fig. 6 B–C).

The sperm pump is pear-shaped with a narrow base; it is composed of two highly sclerotized structures of a cuticular nature.

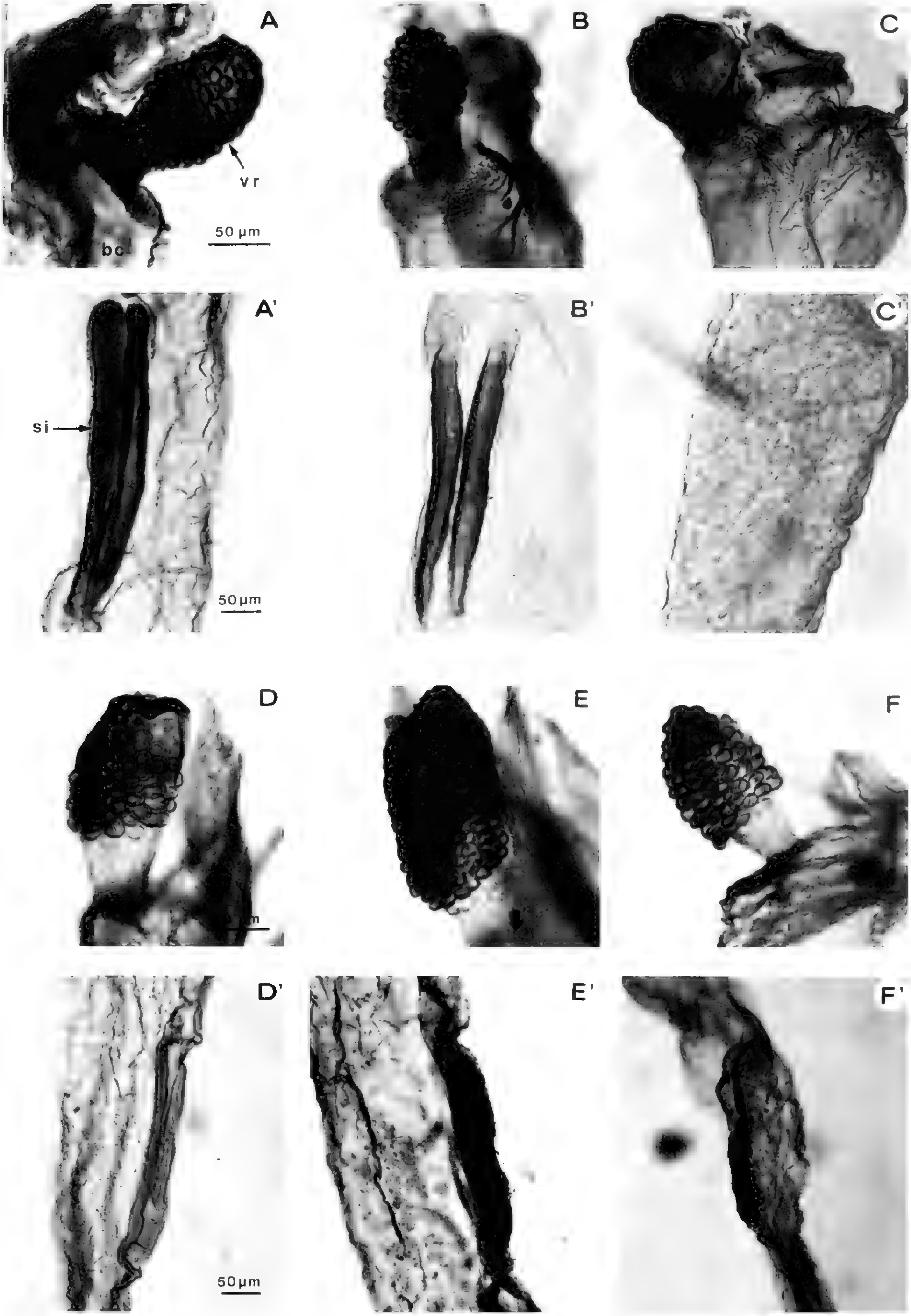

Fig. 2. Microphotographs of the cuticular intima of the *bursa copulatrix* showing the ventral receptacle and area of the vaginal duct near the signum (clorazol black E). A, A', *Anastrepha serpentina*. B, B', *A. striata*. C, C', *A. cordata*. D, D', *A. ludens*. E, E', *A. obliqua*. F, F', *A. fraterculus*. Abbreviations: bc = bursa copulatrix; co = common oviduct; si = signum; vr = ventral receptacle.

Table 3. Comparison of some terminology used for the male reproductive system in the Tephritidae.

Present Study	Hanna (1938)	Drew (1969)	Dodson (1978)	Williamson (1989)	Bressan (1995)	Martínez et al (1995)
Testis	testis	testis	testis	testis	testis	testis
Vas deferens	vas deferens	vas deferens	vas deferens	vas deferens	vas deferens	vas deferens
Ejaculatory duct	vas efferents	ejaculatory duct	common duct	ejaculatory duct	vas efferents	ejaculatory duct
Accessory glands	accessory glands	accessory glands	accessory glands	accessory glands	accessory glands	accessory glands
Seminal vesicles	end of vas deferens	not indicated	not indicated	base of testis	base of testis	not indicated
Sperm pump	pump organ	pump organ	sperm pump	ejaculatory apodeme	ejaculatory apodeme	ejaculatory apodeme
Aedeagal gland	gland	oval gland	not indicated	not indicated	2nd accessory gland	not indicated
Aedeagus	aedeagus	aedeagus	aedeagus	aedeagus	aedeagus	not indicated
Distiphallus	not indicated	not indicated	terminal end	not indicated	not indicated	not indicated

The ejaculatory apodeme is long and spatula-shaped with a thick layer of muscles inserted onto it longitudinally. The other structure is capsule-like and semi-spherical; it surrounds the ejaculatory duct and the ejaculatory apodeme inserts into it (Fig. 6 D). Due to the complexity of this organ, it is very difficult to determine the exact position of the ejaculatory duct.

The aedeagal gland is an unpaired, elongated, and usually voluminous organ. It is formed by glandular units which surround the cuticular glandular reservoir. The basal region of the reservoir thins out slightly and opens into a space between the wall of the ejaculatory duct and the aedeagus, right next to the basiphallus (Fig. 6D). This gland has a very similar shape to that of all other studied tephritid species.

The length of the aedeagus is variable among the species of *Anastrepha* and is probably correlated with the length of the female terminalia in this genus (Norrbom, personal communication). Although a statistical analysis was not performed, for some species aedeagus length was measured and compared with average aculeus length. We found that the species with a long aedeagus has a long aculeus as well. For instance, in *A. fraterculus* and *A. obliqua,* the aculeus is 1.4–1.8 mm long, while the aedeagus is 2.38–2.72 mm long. In contrast, species with long aculeus such as *A. cordata* (4.7–5.5 mm) and *A. ludens* (3.2–5 mm) have an aedeagus length of approximately 6.18 and 5.71 mm, respectively.

The male terminalia involves structures such as the epandrium, proctiger and the inner and outer surstyli. The epandrium is a rigid and very sclerotized structure of semi-spherical shape. In its medial posterior region lies the membranous proctiger, which can be retracted or expanded. The surstyli rise out of the inferior base of the epandrium; both the inner and outer surstyli are partially fused together.

The most important differences among males were observed in structures such as the accessory glands, ejaculatory apodeme, distiphallus and male terminalia.

In the species examined, the accessory glands varied in number, shape and size. *Anastrepha serpentina* has six pairs, *A. striata* four pairs and *A.cordata* only two pairs. In the species of the *fraterculus* group (cf. *A. ludens, A. obliqua* and *A. fraterculus*), seven pairs were observed. Forked long glands are found in *A. serpentina, A.cordata, A. ludens, A. obliqua* and *A. fraterculus*; only *A. striata.* has one pair of simple long glands. Forked medium glands were observed only in *A. serpentina, A. striata, A. obliqua* and *A. fraterculus.* All species, however, have simple medium

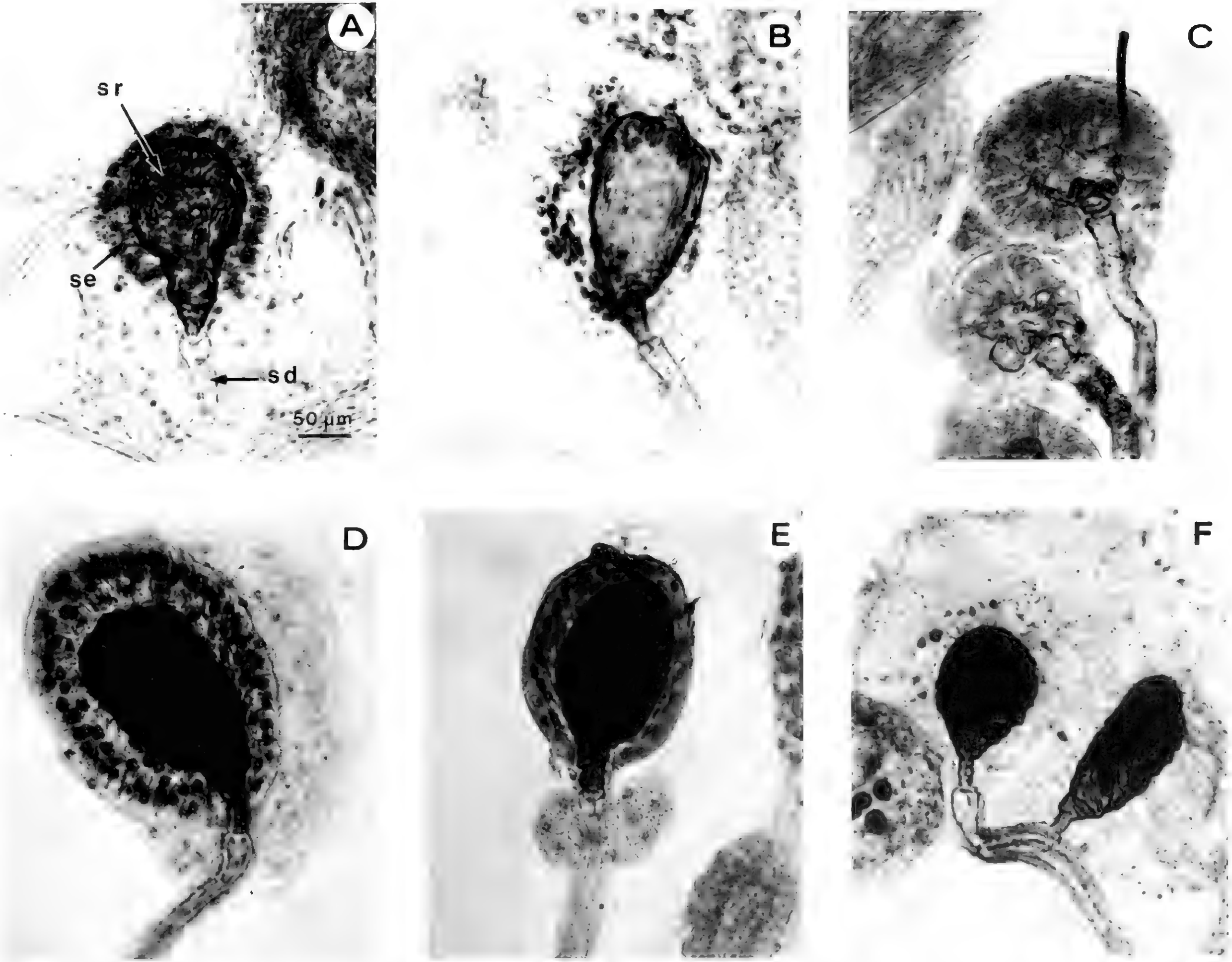

Fig. 3. Microphotographs of the spermathecae (Feulgen-light green). A, *Anastrepha serpentina*. B, *A. striata*. C, *A. cordata*. D, *A. ludens*. E, *A. obliqua*. F, *A. fraterculus*. Abbreviations: se = spermathecal epithelium; spd = spermathecal duct; sc = spermathecal capsule.

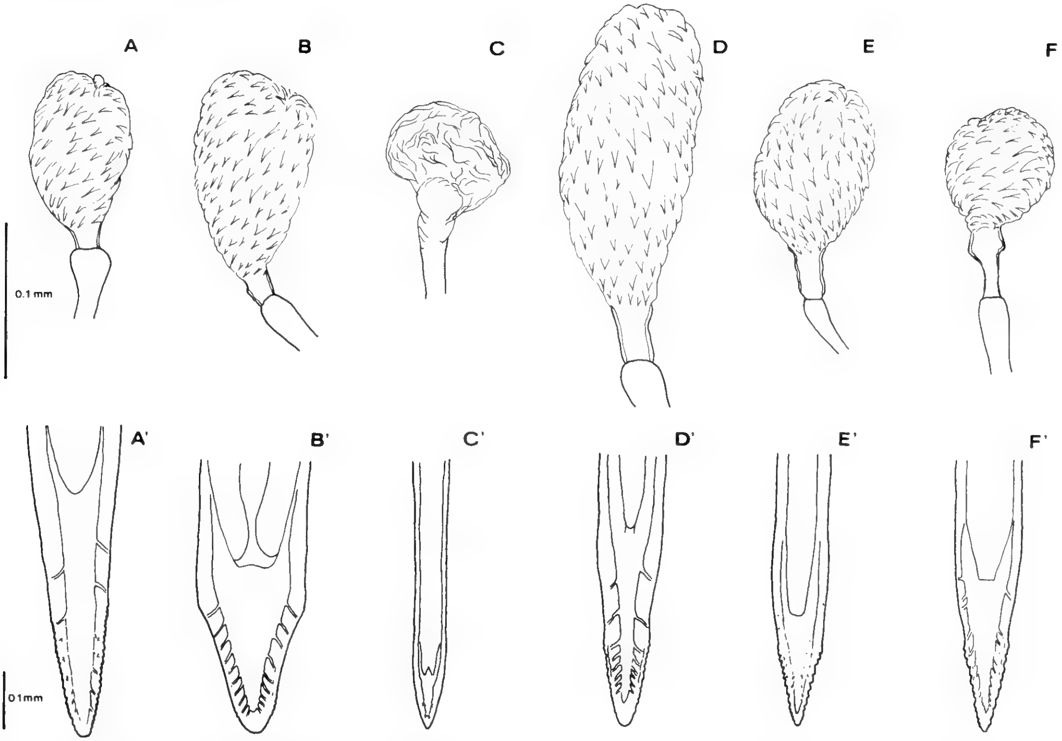

Fig. 4. Outlines of the spermathecal capsules and aculeus tips. A,A', *Anastrepha serpentina*. B, B', *A. striata*. C, C', *A. cordata*. D, D', *A. ludens*. E, E', *A. obliqua*. F, F', *A. fraterculus*.

glands, although in varying number: there is one pair in *A. cordata, A. obliqua,* and *A. fraterculus,* two pairs in *A. striata* and *A.ludens* and four pairs in *A. serpentina.* Only in *A. ludens, A. obliqua* and *A. fraterculus* are there four pairs of small glands. The same number, shape and size of glands are found only in *A. obliqua* and *A. fraterculus.* (Fig. 7, Table 4).

In the mature males studied, the ejaculatory apodeme tends to be narrow in *A. ludens, A. fraterculus,* and *A. striata,* whereas in the others, especially *A. cordata,* is visibly wider at its apical half (Fig. 8). However, the differences should be considered with some reserve, due to the fact that intraspecific size can vary depending on the degree of maturity of each individual (Drew 1969). To study this properly, careful comparison must be made of each species over time, and the results presented should include a range of intraspecific variation.

In general, the distiphallus (Fig. 9) has a bulky basal portion known as the basal lobe, with tiny microspines on its surface. The rest is a membranous, semitransparent unit with an interior sclerotized duct. All *Anastrepha* and *Toxotrypana* species present an internal apical sclerite "T" shaped (sensu Norrbom 1985).

Within the male terminalia, some interspecific differences stand out, particularly the shape of the outer surstyli when viewed laterally. In most of the studied species, they were elongated, except in *A. cordata* in which the surstyli are very short and widened at the base (Fig. 10).

DISCUSSION

The general anatomy of the female reproductive system is similar in all of the studied *Anastrepha* species, as well as other Tephritidae such as *Rhagoletis pomonella* (Dean 1935), *C. capitata* (Hanna 1938), *B.*

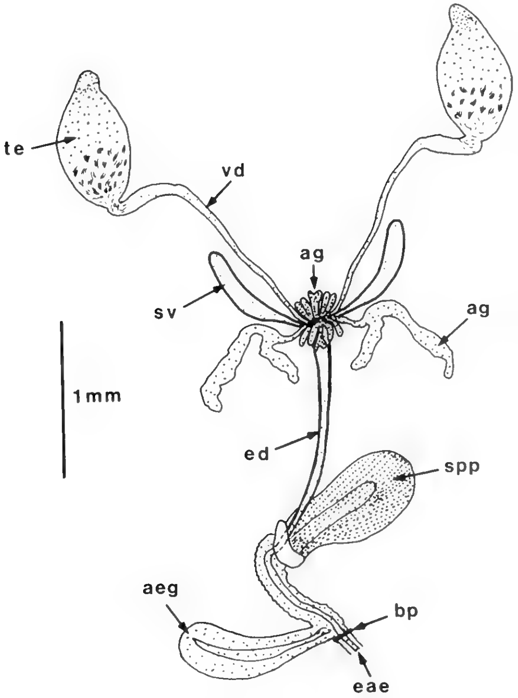

Fig. 5. General morphology of the reproductive system in the male of *Anastrepha serpentina*. Abbreviations: aeg = aedeagal gland; ag = accessory gland; bp = basiphallus; eae = entrance of the ejaculatory duct to aedeagus; ed = ejaculatory duct; spp = sperm pump; sv = seminal vesicles; te = testis; vd = vas deferens.

tryoni (Drew 1969) and *B. oleae* Gmelin (Solinas and Nuzzaci 1984).

The number of ovarioles present in the six species of *Anastrepha* varies between 20 and 33 per ovary. This number is also very similar to that of other species of fruit flies such as *C. capitata,* which has an average of 28 ovarioles (Hanna 1938), *R. pomonella* with an average of 24 (Dean 1935), and *Bactrocera tryoni* with about 22 (Anderson and Lyford 1965). However, species such as *R. conversa* and *R. nova* have an average of 9 and 12 ovarioles, respectively (Flores et al. 1987).

In all *Anastrepha* females, the ovarian follicle contains the oocyte and 15 nutritive cells, similar results were reported previously for *A. obliqua* (Bressan and Costa Teles 1991) and other species such as *B. tryoni* (Anderson and Lyford 1965), *R. conversa* and *R. nova* (Flores et al. 1987).

The anatomy of the vagina in the Tephritidae, except in the case of *R. pomonella* (Dean 1935), has never been clearly described. In *C. capitata* the vagina and vaginal duct were depicted without any mention of the *bursa copulatrix* and the ventral receptacle (Hanna 1938, Guillén 1983). The ventral receptacle was illustrated as an unpaired, sclerotized organ in *X. unipuncta* by Souza Lopes (1939) as well as in other groups of Tephritidae (Munro 1984). In *B. tryoni* this structure was termed the morula gland by Drew (1969).

In the few species of *Anastrepha* studied previously, neither the *bursa copulatrix* nor the ventral receptacle has been adequately described. With respect to *A. suspensa* and *A. ludens,* the posterior region of the vagina was mislabeled the oviduct by Dodson (1978), while Servín-Villegas and Jiménez-Jiménez (1995) believed that the vagina is formed by a widening in the oviduct. In *A.*

Table 4. Comparison of some characteristics of the accessory glands of males of six *Anastrepha* species.

	Accessory glands (pairs)					
	Long		Medium			
Species	Forked	Simple	Forked	Simple	Small	Total
A. serpentina	1	—	1	4	—	6
A. striata	—	1	1	2	—	4
A. cordata	1	—	—	1	—	2
A. ludens	1	—	—	2	4	7
A. obliqua	1	—	1	1	4	7
A. fraterculus	1	—	1	1	4	7

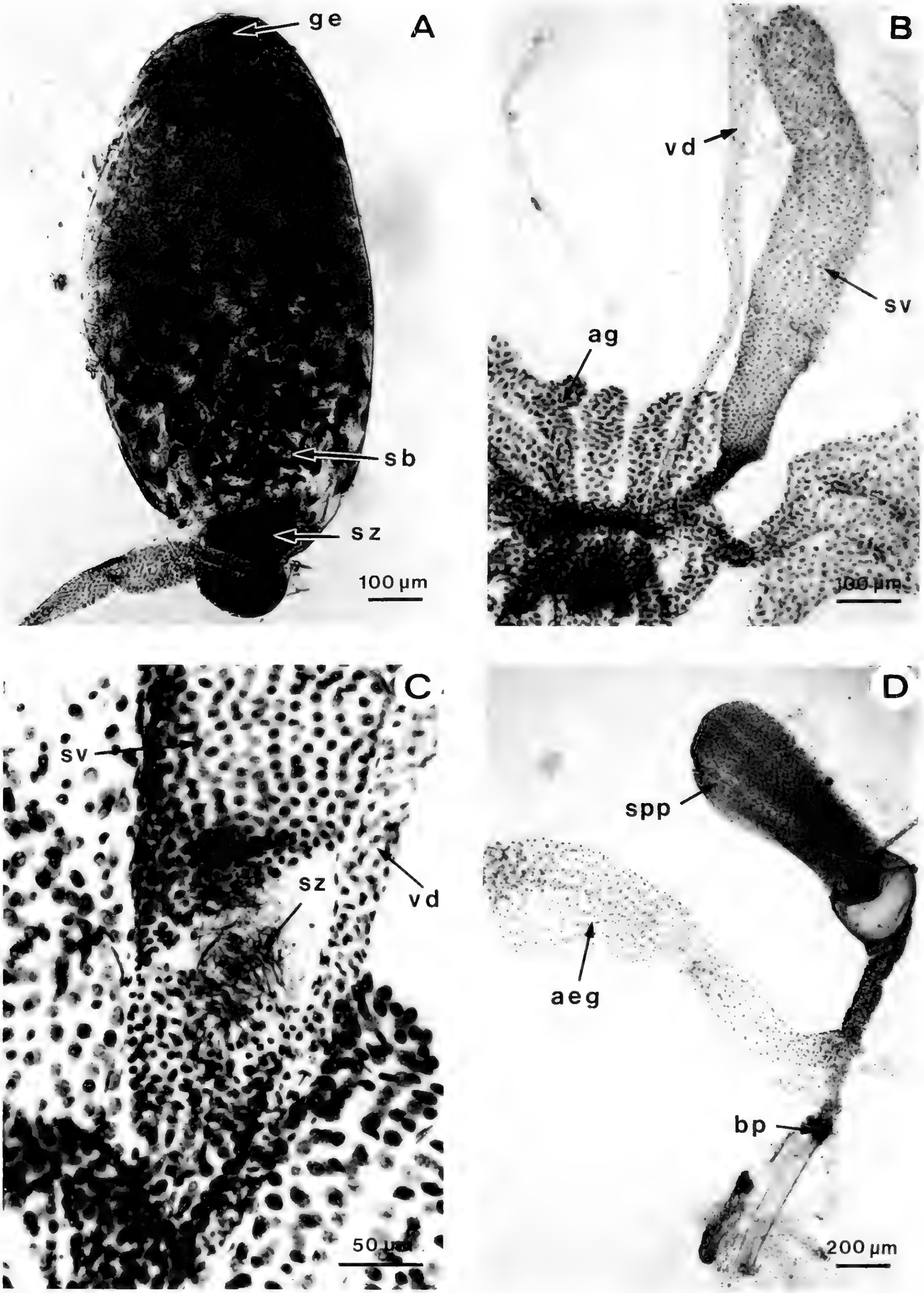

Fig. 6. Microphotographs of some structures of the reproductive system in the male of *Anastrepha serpentina* (Feulgen-light green). A, Testis. B, Accessory glands. C, Seminal vesicles and vas deferens. D, Sperm pump and aedeagal gland. Abbreviations: aeg = aedeagal gland; ag = accessory glands; bp = basiphallus; sb = sperm bundles; spp = sperm pump; sv = seminal vesicles; sz = spermatozoids; vd = vas deferens.

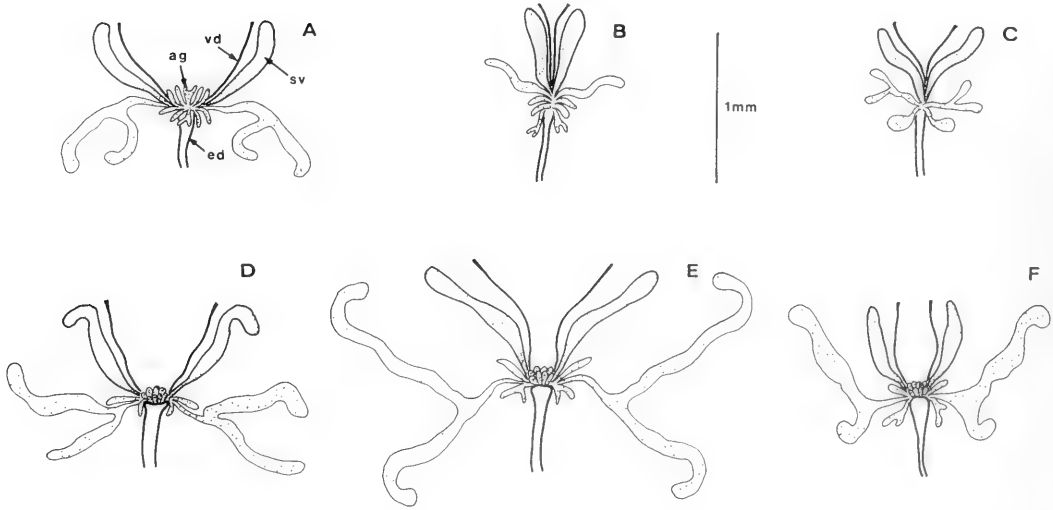

Fig. 7. Outlines of the accessory glands and seminal vesicles. A, *Anastrepha serpentina*. B, *A. striata*. C, *A. cordata*. D, *A. ludens*. E, *A. obliqua*. F, *A. fraterculus*. Abbreviations: ag = accessory glands; ed = ejaculatory duct; sv = seminal vesicles; vd = vas deferens.

serpentina, only the anterior vagina and vaginal duct have been recognized (Martínez et al. 1995).

Other authors such as Dean (1935) and Williamson (1989) characterize the vagina as consisting of two regions: the anterior, which is made up of the *bursa copulatrix* as well as the ventral receptacle, also called the fertilization chamber by Solinas and Nuzzaci (1984). The second is the posterior region, which consists of the vaginal duct.

In insects the *bursa copulatrix* acts as a receptacle for the male intromittent organ (Snodgrass 1935). In *Anastrepha* it receives the distiphallus during copula, but spermatozoids are deposited in the ventral receptacle before being transferred to the spermathecae. The few which remain in the ventral receptacle will be the first spermatozoids to fertilize the eggs (Dean 1935, Solinas and Nuzzaci 1984).

The presence of three spermathecae in all species of *Anastrepha* is characteristic of most Trypetinae (*sensu* Hancock 1986a), except in some species of *Rhagoletis* such as *R, nova* and *R. conversa* (Flores et al. 1987), *R.striatella* Wulp (Bush 1966) and other Carpomyina (Norrbom 1994). In contrast, Dacinae species such as *C. capitata, B. tryoni* and *B. oleae* have only two spermathecae (Hanna 1938, Drew 1969, Solinas and Nuzzaci 1984), as well as all Tephritinae (Hancock 1986b).

Female accessory glands in tephritid females have been misrepresented as colleterial glands by some authors (Hanna 1938, Drew 1968, Flores et al. 1987). This term is employed specifically for the accessory glands of the Orthoptera, in which the colleterial glands are responsible for secreting substances which form the ootheca (Davey 1985a). In Diptera, the function of the accessory glands is poorly understood, except in *Glossina* (Glossinidae), in which they are called milk glands because their secretions serve as nourishment for the intrauterine larvae (Matzuda 1976, Davey 1985a).

For tephritids, the function of the accessory glands is not well understood, although Christenson and Foote (1960) speculated that their secretions act as a vaginal lubricant before oviposition. Solinas and Nuzzaci (1984) mentioned that these secretions can help carry sperm toward the fertilization chamber. It has also been suggested that the accessory glands produce

Fig. 8. Microphotographs of ejaculatory apodemes of the sperm pump (chlorazol black E). A, *Anastrepha serpentina*. B, *A. striata*. C, *A. cordata*. D, *A. ludens*. E, *A. obliqua*. F, *A. fraterculus*.

marking pheromones deposited by the female after oviposition so that other females recognize infested fruit (Prokopy and Roitberg 1984).

The general anatomy of the male reproductive system for *Anastrepha* is similar in all studied species as well as other Tephritidae (Hanna 1938, Souza Lopes 1939, Drew 1969).

As to the location of the seminal vesicles in Tephritidae, various authors (Anwar 1971, Williamson 1989, Bressan 1995, Servín-Villegas and Jiménez-Jiménez 1995) stated that they are located to the basal part of the testis perhaps due to the abundant presence of free spermatozoids. In *C. capitata* they confused the seminal vesicles with the anterior part of the ejaculatory duct (Hanna 1938). As to *X. unipunctata,* Souza Lopes (1939) stated that the seminal vesicles are two structures which open into the anterior region of the ejaculatory duct near the vas deferens.

In mature males of *Anastrepha,* free sper-

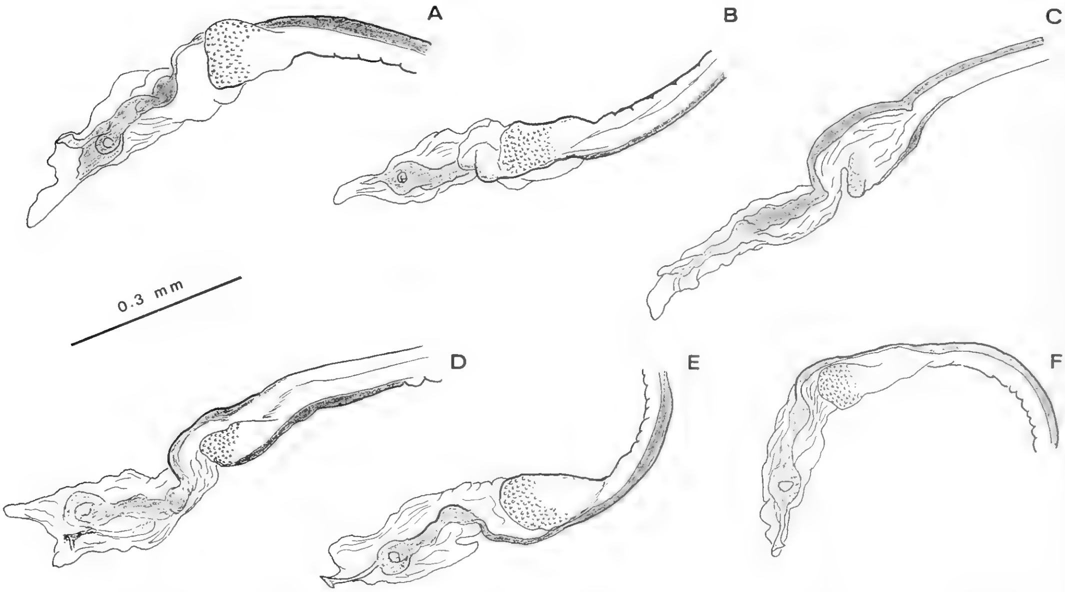

Fig. 9. Outlines of distiphallus. A, *Anastrepha serpentina*. B, *A. striata*. C, *A. cordata*. D, *A. ludens*. E, *A. obliqua*. F, *A. fraterculus*.

matozoids were observed at the base of the testes, all along the vas deferens and in the seminal vesicles. In this genus the seminal vesicles open into the ejaculatory duct parallel to the vas deferens and between the accessory glands, as is the case in other groups of Diptera (see Matzuda 1976). In *Anastrepha* the seminal vesicles have been confused with the accessory glands due to their proximity to them and because no spermatozoids have been observed in the seminal vesicles.Their function for the storage of the mature spermatozoids until the moment of copula is well known in different species of insects (Snodgrass 1935, Davey 1985b).

The accessory glands of *Anastrepha* males has not been described in detail previously. It is quite probable that they are responsible for secreting substances which form the seminal liquid which accompany the spermatozoids; this has been documented for other groups of insects (Davey 1985b). The species examined from the *fraterculus* group all had seven pairs of accessory glands, the highest number observed. The other species had from two to six pairs, and the number differing from species to species (Table 3). In *A. suspensa,* which also belongs to the *fraterculus* group, the existence of three to four pairs was mentioned by Dodson (1978), It is probable that this author did not observe the four pairs of small glands because they are difficult to discern without dye; he may have mistaken one pair for seminal vesicles. For *A. ludens,* Servín-Villegas and Jiménez-Jiménez (1995) reported the presence of four pairs, which in all likelihood correspond to the pair of long glands, two pairs of medium glands and one pair of seminal vesicles. The four small glands were not observed (Table 4).

Xanthaciura unipuncta has only two pairs of accessory glands (Souza Lopes 1939). For *C. capitata,* Hanna (1938) and Valdés Carrasco and Prado Beltrán (1990) described the presence of four pairs, one very long and three short, although we assume that one pair is actually the seminal vesicles. For *B. tryoni,* Drew (1969) described 4 pairs, but one of them also exhibits marked morphological differences which

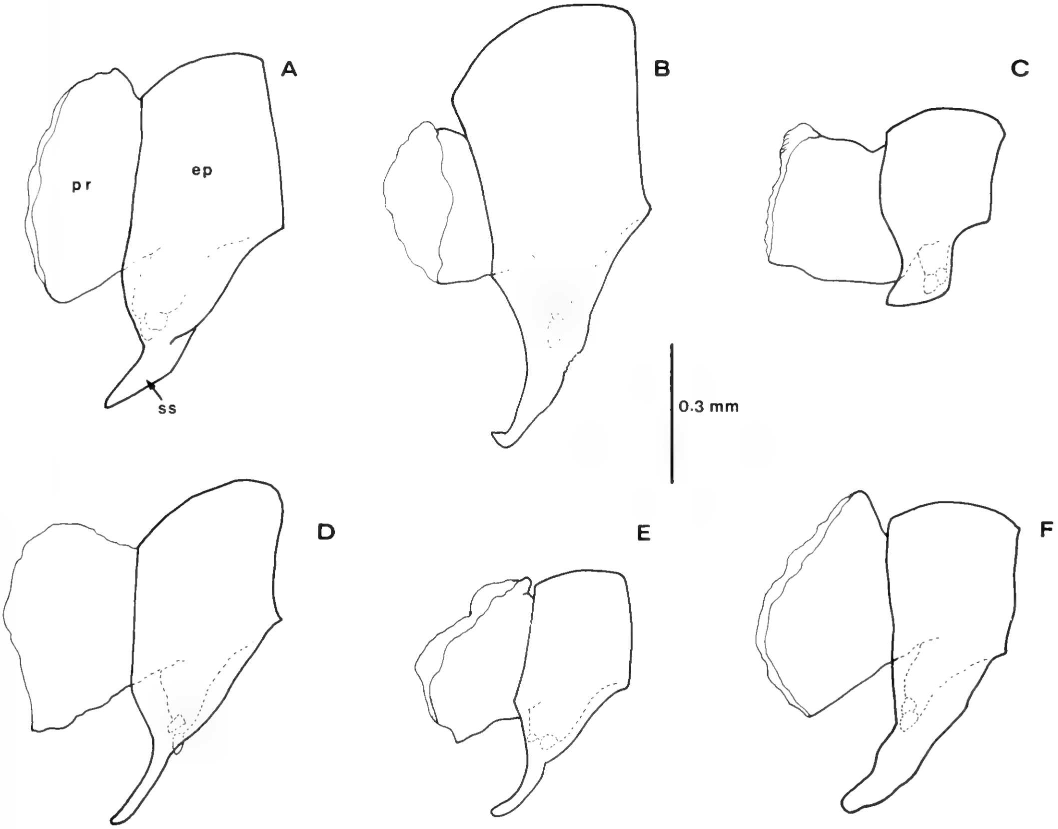

Fig. 10. Simplified outlines of the male genitalia in lateral view. A, *Anastrepha serpentina*. B, *A. striata*. C, *A. cordata*. D, *A. ludens*. E, *A. obliqua*. F, *A. fraterculus*. Abbreviations: ep = epandrium; pr = proctiger; ss = outer surstyli.

make us believe that they are seminal vesicles.

The sperm pump is made up of a semispherical base to which a sclerotized internal structure called the ejaculatory apodeme is attached; many muscles are inserted onto the apodeme. The sperm pump pumps seminal liquid and distends the aedeagus during copula (Matzuda 1976).

In this respect, most studies of Tephritidae call the sperm pump the ejaculatory apodeme, while other authors such as Hanna (1938) and Drew (1969) call it the erecting and pumping organ.

In all *Anastrepha* species examined, the aedeagal gland corresponds to the oval-shaped gland described for *C. capitata* by Hanna (1938), and to the second accessory gland indicated by Bressan (1995) for *Anastrepha* spp. Given its glandular anatomical characteristics and because it opens into a region between the ejaculatory duct and the aedeagus at the base of the basiphallus, its secretions must empty into this space. The secretions may function as a lubricant, as suggested by Hanna (1938), and may also serve to distend the aedeagus during copula.

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AIVALYKUS DOMINICANUS (HYMENOPTERA: BRACONIDAE), A NEW SPECIES FROM DOMINICAN AMBER

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Abstract.—***Aivalykus dominicanus,* n. sp.,** is described from two male specimens preserved in Dominican amber, and represents the first described species of the genus from the Neotropics. The specimens are 15–45 million years old. The new species is remarkable by the elongated abdominal terga (longer than the rest of the body), and is distinguished from the four extant *Aivalykus* species by a more elongated first abdominal tergite and differences in fore wing venation.

Key Words: Braconidae, *Aivalykus dominicanus* n. sp., fossils, Dominican amber

The genus *Aivalykus* Nixon 1938 (Hymenoptera: Braconidae) is placed in the Doryctinae, tribe Hecabolini, and can be distinguished from other genera of the tribe by the following combination of characters: males with elongated abdominal terga, femora not swollen, fore wing with nervulus present, stigmal length greater than 2 times width, radius reaching wing margin, discoideus and subdiscoideus interstitial. The genus contains four extant species from the Indo-Pacific, Malagasy and Nearctic regions. Males are known from only two species, *A. eclectes* Nixon (the genotype) and *A. nearcticus* Marsh, that are remarkable for their elongated abdomens (Nixon 1938, Marsh 1965). We have examined two male *Aivalykus* specimens imbedded in Dominican amber. These represent a new species, which is described below.

These specimens originated from mines located in the Cordillera Septentrional, between Santiago and Puerto Plata, in the northern portion of the Dominican Republic. These mines are in the El Mamey Formation (Upper Eocene), which is a shale-sandstone interspersed with a conglomerate of well-rounded pebbles (Eberle et al. 1980). The exact age of the amber is unknown, but estimates based on various microfossils and chemical analyses provide a range from 15–20 million years (Iturralde-Vinent and MacPhee 1996) to 30–45 million years (Cepek in Schlee 1990).

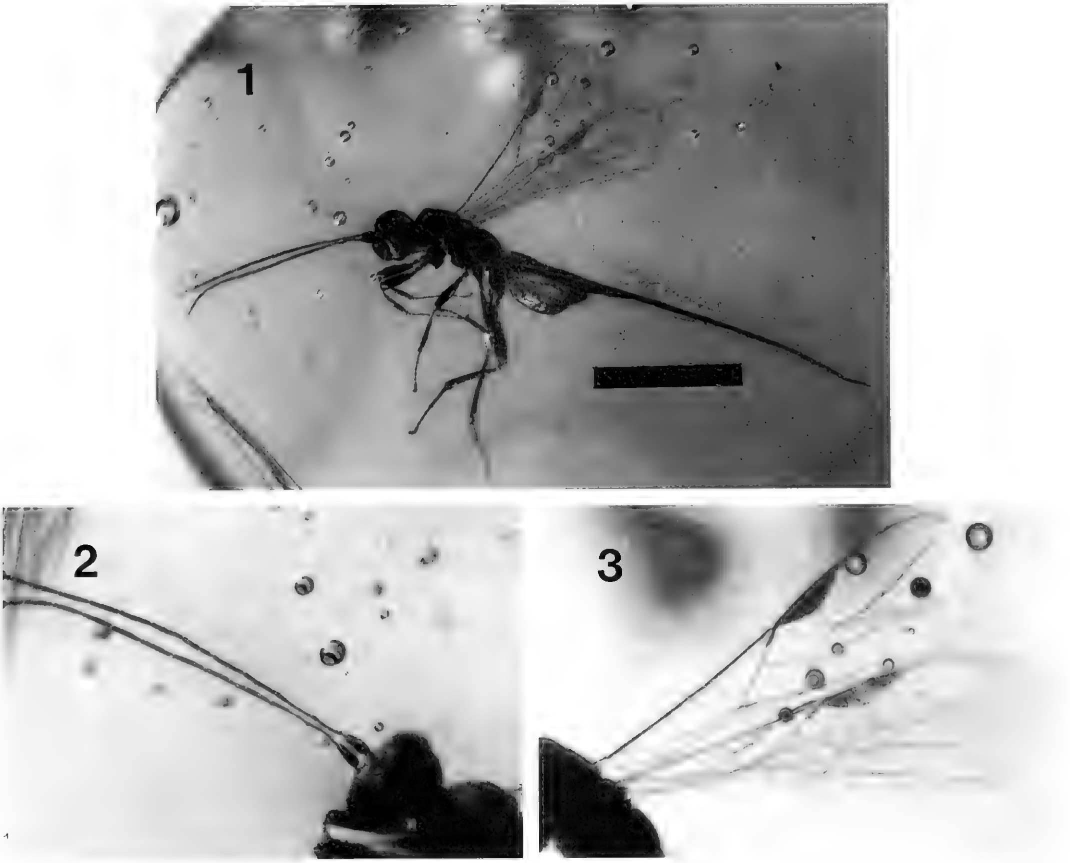
Aivalykus is the fourth genus (along with *Hecabolus* Haliday, *Polystenus* Forster and *Promonolexis* Brues, all known from European Oligocene specimens) in the Hecabolini represented by fossil remains; additional doryctinine genera with recorded fossils include *Ecphylus* Forster (from Mexican amber, 22–26 mya), *Doryctes* Haliday (from Baltic amber, 40 mya) and *Rhaconotus* Ruthe (from Florissant beds, 34 mya) (Carpenter 1992).

Terminology of wing venation follows Marsh et al. (1987). Specimens were studied immersed in corn oil.

Aivalykus dominicanus Zuparko and Poinar, New Species

(Figs. 1–3)

Diagnosis.—Length of first abdominal tergite 2.5 times its apical width, and re-



Figs. 1–3. *Aivalykus dominicanus* (male). 1, Habitus (Scale bar = 1.0 mm). 2, Dorsal aspect of antennae. 3, Fore wings.

current vein of fore wing received into 1st cubital cell by a distance about ¼ its own length. The four other described *Aivalykus* species have length of first tergite less than 2.5 times apical width; recurrent vein of *A. eclectes* is interstitial or received into 2nd cubital cell, that of *A. niger* Granger into the 2nd cubital cell, and that of *A. nearcticus* received into 1st cubital cell by a distance equal to about ½ its length. Additionally, fore wing stigma of *A. dominicanus* is less than 4 times its width (greater than 4 times its width in *A. niger*), in profile dorsum of mesonotum very flat (rounded in *A. nearcticus*), and the sternaulus extends over the greater part of the mesopleuron (absent in *A. sperches* Nixon).

Description.—Male (habitus; Fig. 1): overall length (inclusive of abdominal terga), 3.5–4.0 mm; body length (exclusive of abdominal terga posterior to last abdominal sternum), 1.5 mm. Apparently bronze, with scape, central portion of frons, propleuron, ventral portion of mesopleuron, propodeum, central portion of anterior sterna and legs (except tarsi), darkened. Head about twice as wide as long, narrower behind eyes than across vertex, vertex finely reticulate. Relative length: width of antennal segments: scape—4 × 2.5, pedicel—3 × 2, first funicular segment (F1)—8 × 1, F2—9 × 1, remaining funicle segments—6–7 × 1 (antennae broken after F11); from dorsal apsect, F1 medially curved markedly inward, F2 curved slightly less so (Fig. 2).

Mesosoma approximately equal in length

to metasoma (exclusive of projecting terga which are about 3 × its length). Apical margin of pronotum with short upturned transparent lamella. In profile, mesonotum anteriorly declining almost perpendicularly to pronotum, remainder of mesonotum, scutellum and anterior part of propodeum very flat, laying along one plane, posterior part of propodeum sloping down at an angle of about 30°. Small lateral dorsal tubercle on mesonotum at junction of longitudinal and perpendicular planes; notauli distinct, converging posteriorly; mesonotum finely reticulate. Mesopleuron smooth, sternaulus extending about 70% length of sclerite. No indication of metanotal spine, propodeum appearing smooth. Fore coxa globular, mid coxa about 1.5 times longer than wide, hind coxa about 2 times longer than wide; femora not swollen, 1st segment of tarsi about twice length of 2nd segment on all legs. Fore wing (Fig. 3): recurrent vein entering first cubital cell by a distance about ¼ its own length; length of stigma less than 4 times its width; parastigma appearing as a widening of the basal vein, extending from the stigma about ½ the distance to the cubitus; 2nd abcissa of radius slightly upcurved, forming an obtuse angle of about 130° with first abcissa; nervulus faint, entering 1st discoidal cell; cubitus strongly pigmented for about 40% its length past the 1st intercubitus, very lightly pigmented thereafter; 1st brachial cell open; subdiscoideus strongly pigmented for about 30% its length past 1st recurrent vein, lightly pigmented thereafter.

Length of first abdominal tergum about 2.5 times its width, widening slightly posteriorly; smooth over most of its surface, slightly excavated posteriorly with short longitudinal striations posteriorlaterally. Second abdominal tergum about 2 times long as wide, narrowing slightly posteriorly. All succeeding terga several times longer than wide, more or less parallel sided, terminal tergum triangular, narrowing apically. Terminal sternum extending slightly past second tergum.

Female—Unknown.

Material examined—Holotype, a well-preserved male in a dark yellow piece of amber, 15 × 7 × 7 mm, number H-10-93. From Cordillera Septentrional, between Santiago and Puerto Plata, in the Dominican Republic. Deposited in the Poinar amber collection maintained at Oregon State University, Corvallis, Oregon.
Paratype, 1 ♂, in very poor condition, in a very light yellow piece of amber, 20 × 11 × 7 mm, number H-10-93A. Collection and deposition data same as holotype.

Etymology—The specific epithet *dominicanus,* a neolatin noun in apposition, refers to the Dominican Republic, the country of origin of the specimens.

DISCUSSION

Except for the terminal antennal segments, the holotype is virtually complete and viewable from several angles. The paratype is in extremely poor condition and is recognizable solely by the flattened extended abdominal terga.

Of the four extant *Aivalykus* species, two (*A. niger* Granger and *A. sperches* Nixon) have unknown hosts, and are described only from female specimens. The other two species (*A. eclectes* and *A. nearcticus*) are associated with bark beetles (Coleoptera: Scolytidae) and characterized by sexually dimorphic abdominal shapes (Beeson 1941, Marsh 1965). Like *A. dominicanus,* the males have greatly elongated abdominal terga, though not to the same degree. In all four extant species the females do not have excessively elongated abdomens.

Elongated ovipositors and/or abdomens are common characteristics of female parasitoids which oviposit in or on hosts (such as bark beetles) hidden deep in a substrate, while the conspecific males often have shorter abdomens. Thus the reversal seen in *Aivalykus* (females with short abdomens and males with long abdomens) is highly unusual. This condition may reflect a male mating-behavior strategy to be the first to mate with emerging females. Similar behavior has been found in the Rhyssini (Hymenoptera: Ichneumonidae—parasitoids of deep-boring siricoid wood wasps). Males of *Megarhyssa* and *Rhyssella* (which have bendable abdomens) may increase their reproductive success by being able to remain on the surface of the bark and mate with females before the latter leave the emergence burrow (Godfray 1994). In the case of *Aivalykus,* we theorize the elongated male abdomen reflects the distance the male needs to cover in order to contact the female still in the host gallery. Although one would expect to find a similarly-lengthened abdomen in the female in order to oviposit to the same depth, this is in fact not a necessary condition in bark beetle parasitoids. *Roptrocerus xylophagorum* (Ratzeburg) (Hymenoptera: Pteromalidae) and *Entedon leucogramma* (Ratzeburg) enter bark beetle galleries to oviposit (Reid 1957, Beaver 1966), while *Tomicobia tibialis* Ashmead (Hymenoptera: Pteromalidae) oviposits on adult bark beetles before they enter the galleries (Reid 1957).

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LIFE HISTORY AND DESCRIPTION OF IMMATURE STAGES OF *TRUPANEA SIGNATA* FOOTE (DIPTERA: TEPHRITIDAE) ON *GNAPHALIUM LUTEO-ALBUM* L. IN SOUTHERN CALIFORNIA

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Abstract.—*Trupanea signata* L. is a narrowly oligophagous, multivoltine, gregarious, obligately gallicolous fruit fly (Diptera: Tephritidae) studied in southern California on *Gnaphalium luteo-album* L. This host plant is an introduced weedy annual of Old World origin to which this tephritid has transferred from indigenous, congeneric hosts, an uncommon occurrence among nonfrugivorous North American Tephritidae. The egg, third-instar larva, and puparium are described and figured. The eggs are inserted into apical and axillary buds. From one to six larvae feed gregariously within an open cavity in the expanded pith parenchyma of galls on axillary branches and stems during all three instars. The galls are elongate-obclavoidal, sometimes bear axillary branches and flower heads, and are covered by a wooly investiture. Pupariation occurs inside the gall. The adults emerge and exit the gall through a common channel by pushing aside a thin, pre-formed, apical, "gall cap." The adults are long-lived and are the overwintering stage. The life cycle follows the aggregative pattern and at least two generations, one each in spring and fall, are produced annually on *G. luteo-album.* Two species of solitary, larval-pupal, hymenopterous endoparasitoids are reported: *Eurytoma* sp. (Eurytomidae) and *Pteromalus* sp. (Pteromalidae).

Key Words: Insecta, *Trupanea, Gnaphalium,* biology, taxonomy of immature stages, galls, oligophagy, parasitoids

The genus *Trupanea* (Diptera: Tephritidae) occurs worldwide and is a numerically large and widespread taxon of nonfrugivorous fruit flies in North America and California (Foote and Blanc 1963, Foote et al. 1993). As such, the adults are among the most commonly encountered, reared or swept tephritids; however, the life histories of most species remain little known, and several species are difficult to distinguish morphologically (Foote 1960, Foote et al. 1993). Detailed life histories of five species of *Trupanea* from southern California have been published (Cavender and Goeden 1982, Goeden 1987, 1988, Headrick and Goeden 1991, Knio et al. 1996b), and the immature stages of three of these species also described (Cavender and Goeden 1982, Headrick and Goeden 1991, Knio et al. 1996a). This and our next five papers will more than double the number of species of *Trupanea* for which life histories and immature stages are well known, beginning here with the indigenous, obligate gall-former, *T. signata* Foote.

MATERIALS AND METHODS

Our field studies on *T. signata* mainly focused on laboratory dissections of galls collected on *Gnaphalium luteo-album* L. at different locations in central and southern California during 1989–91: (1) N end of

Hemet Lake at 1424-m elevation, San Bernardino Nat. Forest (S section), Riverside Co., 29.ix.1989 and 11.ix.1990; (2) along Deer Creek in the Morton Flat area at 550 m. Tulare Co., 14.vi.1990; (3) Box Springs Grade between Moreno Valley and Riverside at 470 m, Riverside Co., 20–28.ii.1991. Excised galls and uprooted gall-bearing shoots were transported in cold-chests in an air-conditioned vehicle to the laboratory and stored under refrigeration for subsequent dissection, photography, description, and measurement. Fifteen eggs recovered from ovipositional cagings and two second- and eight third-instar larvae, and four puparia dissected from galls were preserved in 70% EtOH for scanning electron microscopy (SEM). Additional puparia were placed in separate, glass shell vials stoppered with absorbant cotton and held in humidity chambers at room temperature for adult and parasitoid emergence. Specimens for SEM were hydrated to distilled water in a decreasing series of acidulated EtOH. They were osmicated for 24 h, dehydrated through an increasing series of acidulated EtOH and two, 1-h immersions in Hexamethlydisilazane (HMDS), mounted on stubs, sputter-coated with a gold-palladium alloy, and studied with a JEOL JSM C-35 SEM in the Department of Nematology, University of California, Riverside.

Most adults reared from isolated puparia were individually caged in 850-ml, clear-plastic, screened-top cages with a cotton wick and basal water reservoir and provisioned with a strip of paper toweling impregnated with yeast hydrolyzate and sucrose. These cages were used for longevity studies, and those with the wicks wrapped around root-bearing shoots of *G. luteo-album* for oviposition studies, in the insectary of the Department of Entomology, University of California, Riverside, at 25 ± 1°C, and 14/10 (L/D) photoperiod. Virgin male and female flies obtained from emergence vials were paired (n = 16) in clear-plastic petri dishes provisioned with a flattened, water-moistened pad of absorbant cotton spotted with honey (Headrick and Goeden 1991, 1994) for observations of their courtship and copulation behavior.

Plant names used in this paper follow Munz (1974, as updated by Hickman 1993); tephritid names and adult terminology follow Foote et al. (1993). Terminology and telegraphic format used to describe the immature stages follow Knio et al. (1996a) and Goeden and Teerink (1996a, b, c, 1997a, b) and our earlier works cited therein. Means ± SE are used throughout this paper. Voucher specimens of *T. signata* and its parasitoids reside in the research collections of RDG; preserved specimens of eggs, larvae and puparia are stored in a separate collection of immature Tephritidae maintained by JAT.

RESULTS AND DISCUSSION

TAXONOMY

Adult.—*Trupanea signata* was described from reared and swept adults collected from various locations in California by Foote (1960), who also pictured the wing of a female. Foote et al. (1993) illustrated the head of an adult in side view and the wing pattern of a female, and noted that the wing pattern of the male ". . .does not differ from that of the female in any important respect."

Immature stages.—*Egg*: Twenty-one eggs of *T. signata* were white, opaque, smooth; with an elongate-ellipsoidal body, 0.69 ± 0.005 (range, 0.65–0.74) mm long, 0.21 ± 0.004 (range, 0.17–0.23) mm wide, smoothly rounded at tapered posterior end, and with a peg-like anterior pedicel, 0.02 mm long (Fig. 1); a single row of aeropyles circumscribes the pedicel (Fig. 1).

The egg of *T. signata* is similar in shape to the eggs of other *Trupanea* species previously described. The egg is larger in width and length than *T. californica* Malloch, approximately the same size as *T. imperfecta* (Coquillett), and shorter than *T. conjuncta* (Adams), *T. bisetosa* (Coquillett) and *T. nigricornis* (Coquillett) (Goeden

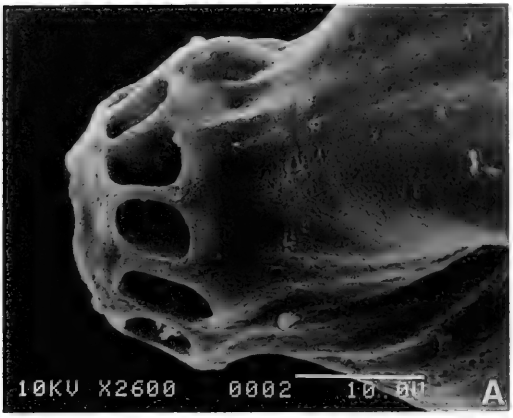

Fig. 1. Egg of *Trupanea signata:* pedicel with aeropyles.

1987, 1988; Headrick and Goeden 1991; Knio et al. 1996a). The single row of aeropyles circumscribing the pedicel is similar to *T. nigricornis,* whereas, *T. bisetosa* commonly has two rows of aeropyles (Knio et al. 1996a).

Third instar: White, barrel-shaped, tapering anteriorly, rounded posteriorly; minute acanthae circumscribe each thoracic and abdominal segment anteriorly, gnathocephalon conical (Fig. 2A), rugose pads dorsally and laterally, rugose pads laterad of mouth lumen serrated on ventral margin (Fig. 2A-1); dorsal sensory organ consists of a single dome-shaped papilla (Fig. 2A-2, B-1); anterior sensory lobe bears four sensory organs, lateral sensory organ with a distinct central papilla (Fig. 2B-2); stomal sense organ ventrolaterad of anterior sensory lobe (Fig. 2B-3); mouth hooks tridentate; rugose pads circumscribe prothorax posteriorly of minute acanthae (Fig. 2C-1), single row of verruciform sensilla circumscribe prothorax medially (Fig. 2C-2); anterior thoracic spiracles on posterior margin of prothorax, bear 4–5 rounded papillae (Fig. 2C-3, 2D); metathoracic lateral spiracular complex consists of a spiracle and a single verruciform sensillum; abdominal lateral spiracular complex consists of a spiracle (Fig. 2E-1), a verruciform sensillum (Fig. 2E-2), and placoid-type sensillum (Fig. 2E-3); caudal segment smooth medially, circumscribed anteriorly by minute acanthae (Fig. 2F-1); posterior spiracular plates (Fig. 2F-2), with three ovoid rimae, ca. 0.038 mm in length (Fig. 2G-1), and four interspiracular processes each with 3–6 branches, longest measuring 0.013 mm (Fig. 2G-2); intermediate sensory complex ventrad of posterior spiracular plates among the minute acanthae (Fig. 2F-3), consist of a medusoid sensillum (Fig. 2H-1), and a stelex sensillum (Fig. 2H-2).

Trupanea signata is similar in general appearance to other described species, i.e., *Trupanea californica* (Headrick and Goeden 1991), *T. bisetosa* and *T. nigricornis* (Knio et al. 1996a). The anterior portion of the prothorax is circumscribed by minute acanthae and rugose pads, which appear to be characteristic of the genus *Trupanea* (Headrick and Goeden 1991, Knio et al. 1996a). Differences among *Trupanea* species described to date are found in the abdominal lateral spiracular complex. This complex in *T. californica* includes a single verruciform sensillum; in *T. nigricornis,* two verruciform sensilla; and in *T. bisetosa,* two verruciform sensilla and a placoid type sensillum (Headrick and Goeden 1991, Knio et al. 1996a). *Trupanea signata* also differs slightly in the number of branches in the interspiracular processes; *T. californica* and *T. bisetosa* possess 6–8 branches, *T. nigricornis* is similar to *T. signata* in having 3–6 branches (Headrick and Goeden 1991, Knio et al. 1996a).

Puparium: Puparium of *T. signata* shiny black, elongate-ellipsoidal, anterior end bears the invagination scar (Fig. 3A-1), and anterior thoracic spiracles (Fig. 3A-2), caudal segment bears the posterior spiracular plates (Fig. 3B-1), a band of minute acanthae (Fig. 3B-2), and the intermediate sensory complex (Fig. 3B-3). Forty-four puparia of *T. signata* averaged 3.23 ± 0.04 (range, 2.55–3.80) mm in length; 1.48 ± 0.03 (range, 1.10–2.35) mm in width.

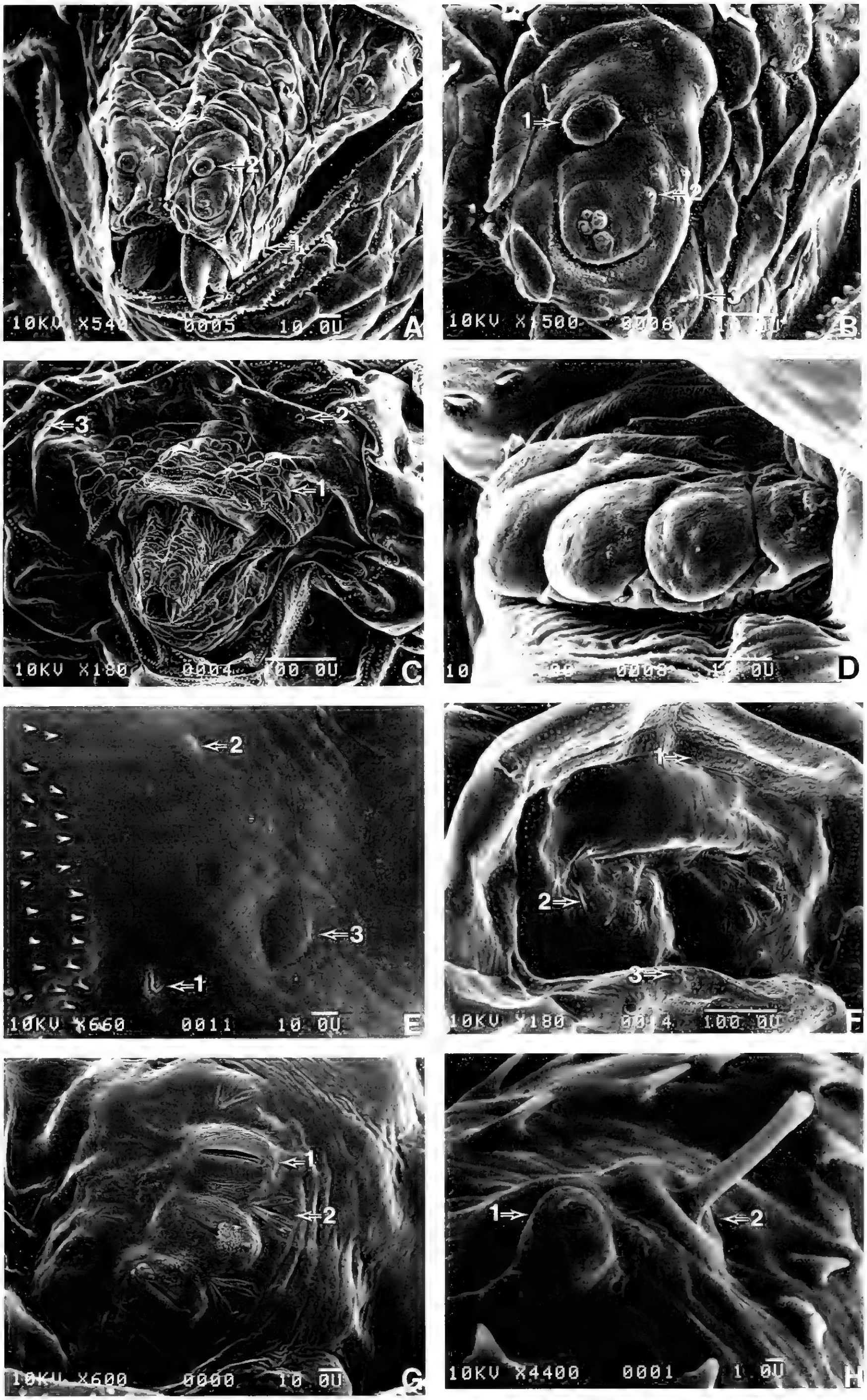

Fig. 2. Third instar of *Trupanea signata:* (A) gnathocephalon, anterior view, 1—serrated rugose pads, 2—dorsal sensory organ; (B) anterior sensory lobe, 1—dorsal sensory organ, 2—lateral sensory organ, 3—stomal sense organ; (C) anterior view, 1—prothoracic rugose pads, 2—verruciform sensilla, 3—anterior thoracic spiracle; (D) anterior thoracic spiracle; (E) fourth abdominal segment, lateral spiracular complex, 1—spiracle, 2—verruciform sensillum, 3—placoid-type sensillum; (F) caudal segment, 1—minute acanthae, 2—posterior spiracular plate, 3—intermediate sensory complex; (G) posterior spiracular plate, 1—rima, 2—interspiracular process; (H) intermediate sensory complex, 1—medusoid sensillum, 2—stelex sensillum.

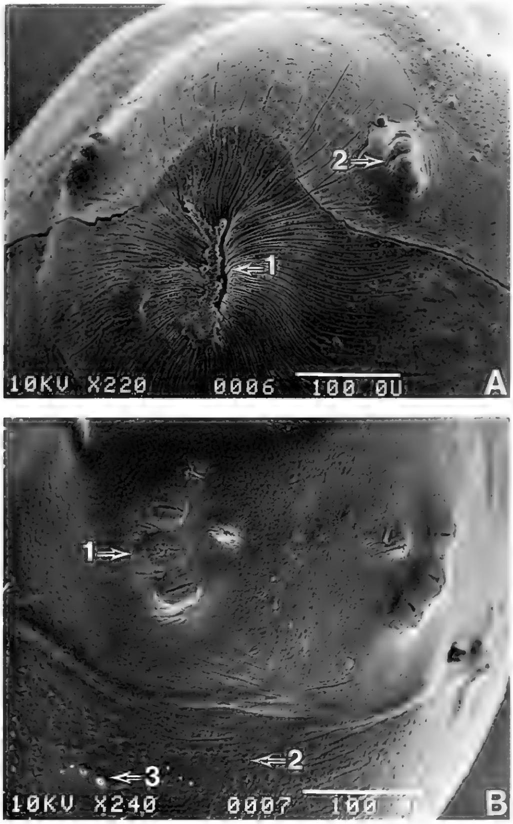

Fig. 3. Puparium of *Trupanea signata:* (A) anterior end, 1—invagination scar, 2—anterior thoracic spiracles; (B) caudal segment, 1—posterior spiracular plate, 2—minute acanthae, 3—intermediate sensory complex.

Distribution and Hosts

The distribution of *T. signata* mapped by Foote et al. (1993) included the western U.S. north of Mexico and Canada, with this species recorded from Arizona, California, Colorado, Nebraska, New Mexico, Oregon, Texas, and Washington as well as British Columbia. Foote (1960) and Foote et al. (1993) reported *Anaphalis* sp. and *Gnaphalium stramineum* Kunth as hosts, besides *G. luteo-album* reported by Goeden (1992). *Gnaphalium luteo-album* is an introduced annual plant species of Old World origins (Munz 1974). Thus, *T. signata* like *T. californica* (Headrick and Goeden 1991), provide examples of indigenous, oligophagous tephritids that have adopted this nonindigenous, host-plant species that is congeneric with native hosts in the southern California flora (Munz 1974). Besides *Campiglossa genalis* (Thomson) on *Senecio* spp. (Goeden et al. 1994), few other examples of such host-plant transfer by indigenous, oligophagous, nonfrugivorous Tephritidae have been documented (Goeden 1996). The biological significance of the sweep record for a female of *T. signata* reported by Goeden (1986) and Foote et al. (1993) was its location on Santa Cruz Island, not the nonhost, *Baccharis pilularis* de Candolle from which it was swept, which like all-too-many sweep records for adult, nonfrugivorous Tephritidae are poor and often misleading indicators of reproductive-host-plant affinities. Accordingly, *T. signata* is oligophagous on certain species of *Anaphalis* and *Gnaphalium* of the subtribes Cassiniinae and Gnaphaliinae, respectively, and the tribe Gnaphalieae of the Asteraceae (Bremer 1994). Unlike *T. conjuncta, T. signata* apparently is an obligate, not a facultative gall former, and has not been reared from flower heads of *Anaphalis* or *Gnaphalium* spp. (Foote 1960, Foote et al. 1993, Goeden 1983, 1987, 1992, unpublished data). Also, our study sites 1 and 2 were in grazed, disturbed, riparian areas and site 3 was in a regularly and well irrigated, roadside flower bed, so all galled plants were well-watered.

Biology

Egg.—Eggs were inserted pedicel-last, singly or side-by-side, in small clusters of two to four for ca. two-thirds their lengths in terminal buds of stems or upper axillary branches (Fig. 4A). Unlike *T. conjuncta,* which also forms galls, the egg clusters were not glued together posteriorly (Goeden 1987).

Larva.—Newly-hatched first instars tunnelled basipetally into the pith of the stem or axillary branch to which they confine their feeding (Fig. 4B–D). The larvae feed singly or gregariously in open, elongate central cavities on proliferating pith paren-

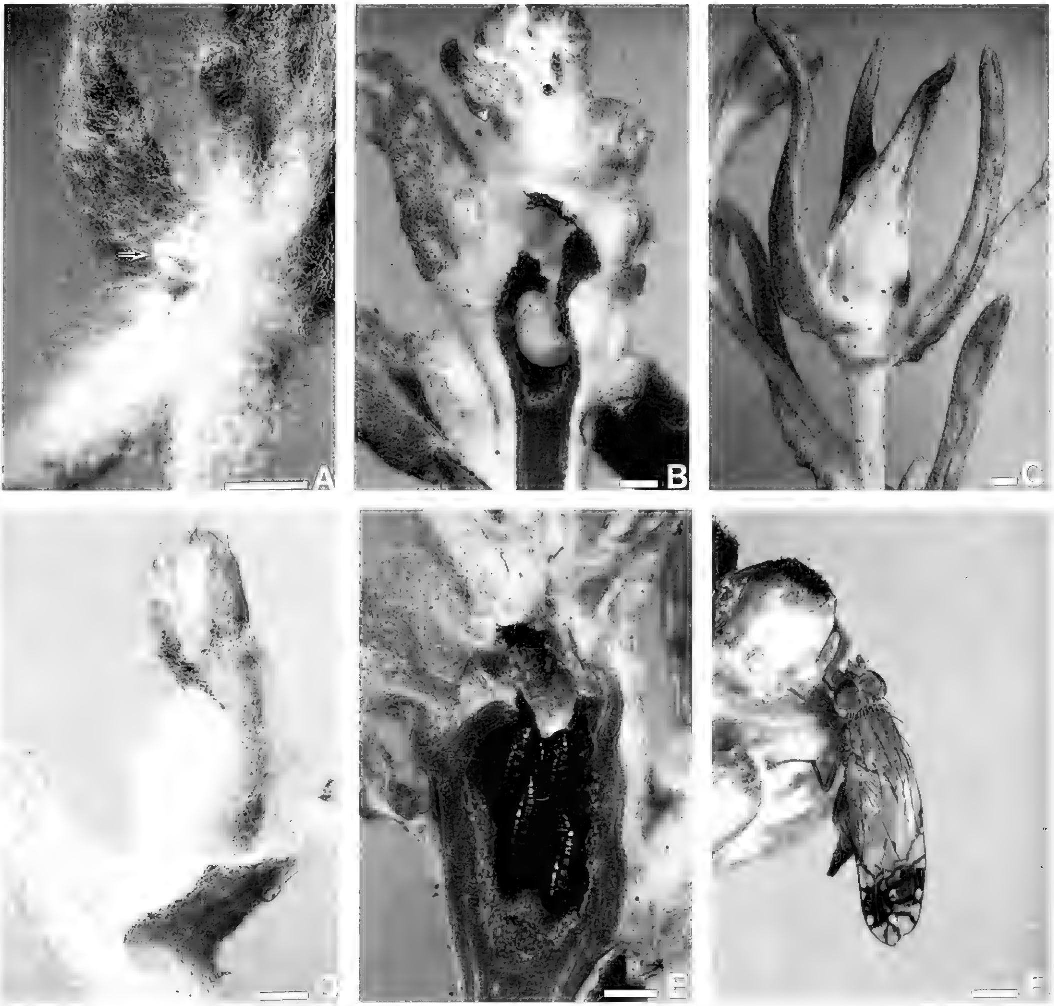

Fig. 4. Life stages of *Trupanea signata* on *Gnaphalium luteo-album:* (A) pair of eggs (arrow) inserted in axillary bud, (B) third instar in feeding cavity below partially dislocated gall cap, (C) exterior view of apical bud gall, (D) gall of axillary branch with flower head at apex, (E) Four puparia in common feeding cavity below apical exit channel and gall cap. (F) Female adult at rest. Lines = 1 mm.

chyma (callose tissue), shallowly pitting the walls, and continually expanding the lengths and widths of the cavities during all three stadia (Fig. 4D). The gall cavities remained free of frass and solid waste, except for the discarded cephalopharyngeal skeletons of the first and second instars. The fully grown third instar extends the cavity distally by eating out a 5.2 ± 0.3 (range, 2–8) mm-long, exit tunnel (n = 25) through the shoot tip to just beneath the apex, leaving a hollow, tomentum-covered gall "cap," which it coats inside with voided liquid feces. The feces dry, harden, and hold this cap in place during pupariation (Fig. 4D). The larva then returns to the main gall cavity, where it and other mature larvae within pupariate with their heads facing the gall apex.

Pupa.—One hundred thirteen full-sized galls collected at all three study sites each contained an average of 2 ± 1 (range, 1–6) puparia (Fig. 4–E). These galls were elongate-clavoidal in shape and covered with a whitish tomentum (Fig. 4B, C). They averaged 14.9 ± 0.6 (range, 6.0–41) mm in length and 4.8 ± 0.1 (range, 1.7–7.8) mm in widest width near the apices, expanding gradually distally from a basal, greenish, tomentose, side branch or stem, and incorporating an average of 3.9 ± 0.1 (range, 1–7) nodes. The galled branch or shoot tips were not shortened in length, but rather mainly expanded in width, and like their ungalled counterparts, bore no or from one to five vegetative or floral branches laterally and apically (Fig. 4). Some of these apical branches were killed when the bud caps were formed. The cavities within these mature galls measured 7.1 ± 0.3 (range, 3.1–18.9) mm long by 2.6 ± 0.1 (range, 1.3–6.9) mm in maximum width. Larger galls typically contained the most puparia, which lay freely, touching laterally or apically, within the common cavity (Fig. 4E).

Adult.—Adults emerged through the same exit tunnel after pushing aside the gall cap. Adults were long-lived under insectary conditions, as males averaged 48 ± 15 (range, 21–158) days, and 18 females (Fig. 4F) averaged 74 ± 11 (range, 31–172) days. A 7 week-old female contained 35 full-size ova, and eight 3–4 week-old females laid an average total of 24 ± 4 (range, 7–34) eggs in ovipositional cagings. No free-living adults were observed in nature.

In petri dish arenas, both sexes displayed synchronous and asynchronous supinations along with wing vibrations and hamation. During asynchronous supination, one wing was extended forward 90° to a point perpendicular to the body, and supinated to 90° with respect to the substrate. As the wing was extended it was vibrated in a plane parallel to the wing blade faster than was observed with other *Trupanea* spp. studied (Headrick and Goeden 1994). When the wing reached its maximum forward position, it was held for ca. 1 second, then returned to the resting position, flat upon the dorsum, and held still while the other wing was extended. Male courtship displays began in the mornings, usually after 0900 h PST and ended ca. midday. The courtship display was similar to that described for other species of *Trupanea* by Headrick and Goeden (1991, 1994) and Knio et al. (1996b). Males of *T. signata* regularly hung upside down from the covers of arenas when displaying and distending their abdomens. When the abdomen was distended, it was held flexed and synchronous or asynchronous wing displays were exhibited; however, when a female was near, males always reverted to synchronous wing extensions. Mating was not observed in this species, but see Headrick and Goeden (1994) for descriptions of mating behaviors common to several southern California species of *Trupanea.*

Seasonal history.—The life cycle of *T. signata* in southern California follows the aggregative pattern in which the long-lived adults in reproductive diapause overwinter probably in riparian habitats and aggregate on preblossom host plants during the following spring to mate and reproduce (Headrick and Goeden 1994). A second late-summer or early-fall generation reproduces on flowering shoots of *G. luteo-album,* and another generation or two may be produced on the above-mentioned, or as yet unidentified, alternate host plants, especially at higher elevations.

Natural enemies.—Two species of Hymenoptera were reared from puparia of *T. signata* as solitary, larval-pupal endoparasitoids: *Eurytoma* sp. (Eurytomidae) and *Pteromalus* sp. (Pteromalidae). Among 49 adult parasitoids recovered, nine (18%) were *Eurytoma* sp. and 40 (82%) were *Pteromalus* sp.

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NOTE

Celticecis, a Genus of Gall Midges (Diptera: Cecidomyiidae), Newly Reported for the Western Palearctic Region

Many Holarctic genera of trees and shrubs are host over much of their ranges to particular genera of Cecidomyiidae. As examples, willows host gall midges of *Rabdophaga* and *Iteomyia,* oaks host *Macrodiplosis* and *Polystepha,* and birches host *Semudobia* in both the Nearctic and Palearctic Regions. So many instances of this pattern are known for gall midges that when a gall midge genus is recorded from only part of the range of a Holarctic plant genus, the partial absence may be suspected to reflect a lack of collecting. There are exceptions, one being beech. This tree is infested by gall midges of the genus *Mikiola* in Europe and Japan but apparently not in North America. *Mikiola* may once have occured in North America and become extinct due to the relatively narrow bottleneck beech passed through during the Pleistocene when it was restricted to southern North America.

Hackberries, the genus *Celtis,* are hosts in North America to at least 10 species of gall midges of the genus *Celticecis* that cause complex leaf and twig galls of sometimes bizarre shape (Gagné 1989, The Plant-Feeding Gall Midges of North America, Cornell University Press, Ithaca, New York, xi and 356 pp., 4 pls.). Some of these species were described 100 years ago, although they were combined into a single genus only recently (Gagné 1983, Proceedings of the Entomological Society of Washington 85: 435–438). *Celticecis* is known from Japan (Moser 1965, New York State Museum and Science Service Bulletin 402: i–iv, 1–95 (as *Phytophaga*); Yukawa and Tsuda 1987, Kontyû 55: 123–131), which extends the range of *Celticecis* into the eastern Palearctic. One of us (JCM), pursuing a long-term interest in hackberry galls, obtained from Prof. K. Browicz of the Institute of Dendrology, Kórnik, Poland, galled leaves of *Celtis tournefortii* Lam. collected in Hisarcik, Kayseri, Turkey. On the upper surface of the leaf the galls are about 1.5 mm in height and width and consist of an outer, raised ring and a central, rounded cone protruding from the the center of the ring. On the lower surface of the leaf the gall is a simple convexity about 1.0 mm in height by 1.5 mm in width. Second instars of a presumably undescribed species of *Celticecis* were extracted from these galls. This new record extends the natural range of *Celticecis* into the western Palearctic. That *Celticecis* has not yet been found in relatively well-collected Europe may mean that it became extinct there during the Pleistocene, as might have the gall midges on beech in North America. The galls and the larvae excised from them are deposited in the National Museum of Natural History, Washington, DC.

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NOTE

Range Expansion of the Red Imported Fire Ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), into New Mexico and Extreme Western Texas

The red imported fire ant, *Solenopsis invicta* Buren, has greatly expanded its distribution in the United States since its accidental introduction into the United States from South America in the 1930's (Buren et al. 1974. Journal of the New York Entomological Society 82: 113–124). It currently occurs throughout the southeastern United States from southeastern Virginia (Waller and Vander Meer. 1993. Association Southeastern Biologists Bulletin 40: 88), south to Florida (Callcott and Collins. 1996. Florida Entomologist 79: 240–251) west to Brownsville, Texas (Allen et al. 1993. Southwestern Entomologist 18: 315–316) and Midland, Lubbock, and Ector counties, Texas (Cokendolpher and Phillips. 1989. Southwestern Naturalist 34: 443–449; Porter et al. 1991. Journal of Economic Entomology 84: 866–874; Callcott and Collins 1996). *Solenopsis invicta* is actually a junior synonym of *S. wagneri* Santschi (Bolton. 1995. A New General Catalogue of the Ants of the World, Harvard University Press, p. 388), but we prefer to us *S. invicta,* as the name is so well established. Introduced fire ants can be separated easily from our native fire ants by the presence of a median tooth on the anterior edge of the clypeus.

We report the presence of the red imported fire ant in New Mexico and El Paso, Texas. This species will undoubtedly further infest urban environments in the southwestern United States and finally invade southern California, where it will probably become a major pest.

Specimens were found infesting a home at Taylor Ranch, a west side suburb of Albuquerque, New Mexico, during the summer of 1994. They were apparently brought into the house in a large planter that recently arrived from the Gulf Coast. We know of at least eight cases during 1994 and 1995 when trucks carrying cargo from the southeastern United States were inspected and stopped at the New Mexico/Arizona border. In six cases the trucks were taken to Albuquerque where they were fumigated. In the two other cases, the trucks were fumigated in Gallup, New Mexico. We know of no cases of trucks being stopped or fumigated during 1996. Discussions with pest control operators indicate that these eight cases are only a small fraction of the instances of fires ants found in commerce in New Mexico. This species was also collected at the ghost town of Steins, New Mexico (D. Richman, personal communication). Apparently a backhoe contaminated with soil was refused entry into Arizona and returned to the nearby off-ramp where the soil was removed. Steins is a very arid site, and it would no be expected that *S. invicta* could survive in such a site. The imported fire ant is also found in El Paso, Texas, the westernmost part of Texas. It occurs on the campus of the University of Texas where it nests at the bases of trees. It was also found near the Rio Grande River in El Paso in 1989 (R. Worthington, personal communication). It is not common in El Paso at the present time, but we expect it to become more common the this mesic, urban environment.

The red imported fire ant is not expected to become a major pest in New Mexico and western Texas, but these sites will undoubtedly serve as "stepping stones" for the invasion of the ant into California.

We thank three anonymous reviewers for helpful comments. Voucher specimens will be deposited in the National Museum of Natural History, Smithsonian Institution,

Washington, D.C., the collection of Texas A&M University, College Park, and in our Laboratory for Environmental Biology.

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BOOK REVIEW

Brethren of the Net: American Entomology, 1840–1880. By W. Conner Sorensen. The University of Alabama Press, Tuscaloosa, Alabama, U.S.A. 1995. 357 pp., cloth. ISBN 0-8173-0755-9 $59.95.

The idea of insect collectors during mid-Victorian America may not generate much initial enthusiasm for some readers. However, if one is interested in his or her entomological roots or the contributions of American entomology and entomologists to science, *Brethren of the Net* is an essential read. Sorensen's book provides a fascinating glimpse of the events and contributions that have shaped current scientific thinking and research not only in entomology but in other biological sciences as well. The book contains 12 chapters, two appendices, abbreviations, notes, bibliography, and includes several black and white plates and photographs.

The first chapter (*Entomology in the American Context*) highlights the period before the 1840's. Naturalists like Reaumur and Linnaeus were instrumental in establishing entomology as a special branch in natural history with its own nomenclature, literature, and community of experts. Linnaeus' approach to entomology provided a system of manageable terms for the discipline. While European entomologists flourished and occupied a niche in European zoological science, fewer resources were available for their American counterparts. By the turn of the 18th century, the situation had begun to change. This was due in part to the establishment of various institutions devoted to natural history in the Philadelphia, Boston–Cambridge, and to a lesser degree New York area. The careers of six Americans (John Abbot, Thaddeus William Harris, John Eatton LeConte, Frederick Valentine Melsheimer, John F. Melsheimer, William D. Peck, and Thomas Say) who figured prominently before the generation of 1840 are emphasized. These early workers were among the first Americans to specialize to a similar degree as the European entomologists. American entomologists were no longer content simply to collect specimens for the Europeans. American entomologists were coming in closer contact with one another but they lacked established institutions for practicing scientific entomology.

Chapter Two concentrates on the first American entomological society devoted to the study of insects—The Entomological Society of Pennsylvania. Here the emphasis is on the members that formed the nucleus of the group. Though there were no formal requirements for membership to the organization, the society was somewhat exclusive. The society's correspondence with other individuals with an interest in entomology was very significant. It served as a vital transition institution that bridged a time between a few isolated investigators and the time of specialists associated with large scientific institutions. Members of The Entomological Society of Pennsylvania aspired to advance American entomology in insect systematics primarily by having Americans publish descriptions of American insects. This desire was probably best reflected in John LeConte's announcement of the "American Entomological Declaration of Independence." Eventually LeConte's declaration materialized with the publication of Melsheimer's catalog of Coleoptera. However, with publication of the catalog, the Society began to fade. The Society's main objective in establishing priority for American names in Melsheimer's catalog had been secured.

Of Cabinets and Collections is the title of the third chapter. This chapter is devoted to the details involved in the establishment of the major insect collections of the mid-19th century. The importance of the expanding entomological collections housed at the Museum of Comparative Zoology at Harvard University, the Academy of Natural Sciences of Philadelphia, and the Smithsonian Institution are highlighted. A growing entomological community along with the establishment of these collections was substantial. The westward expansion of the American republic resulted in numerous collection expeditions that yielded large numbers of specimens. A modicum of standardization for insect cabinets and pins and the widespread use of preservatives within the collections kept pests from destroying the holdings. The financial support from state and federal governments and wealthy patrons were important to the entomological collections, as was the donation of large private collections. This was especially the case for the Smithsonian's entomological holdings when C. V. Riley donated his collection (estimated at the time to be the largest general collection in the country) in 1885. By this time, Americans were well on their way to establishing entomological institutions that were comparable to those enjoyed by their European counterparts.

Agricultural Entomologists and Institutions (Chapter 4) elaborates on the transformation of those early "amateur" entomological investigators to paid professionals with an emphasis on public service and practical application. Funding for agricultural entomology and the establishment of instruction of the subject at various institutions was important during this time. In 1863, a course in agricultural entomology taught by Manley Miles at Michigan Agricultural College was apparently the first of its kind. By the early 1870's, course offerings in agricultural entomology appeared in half a dozen colleges across the United States. The fact that the level of support in the United States rose from the great agricultural changes in the nation is noteworthy. The states, federal government, and agricultural colleges offered multiple institutional possibilities for those seeking such support. This support translated into substantial expansion of employment for entomologists.

Chapters 5–7 pertain to the topic of the "balance of nature" or "economy of nature" theory and specific insects that shaped American economic entomology. The balance of nature theory presupposed that God regulated the world through natural checks and balances; it further assumed a harmonious relationship among all living species. Such a species has traits that "enable it to maintain its essential shape (morphology) and to inhabit its geographic range despite challenges form the other species or from the environment." The balance was "upset" by either the introduction of nonnative species or crop monoculture. Chapters six and seven cover in detail specific insects (plum curculio, the Hessian fly, the Colorado potato beetle, and the Rocky Mountain locust (Chapter 7)) that interrupted this "balance" and led to significant advances for the entomological community. During 1840–1870 there was much interest in the relationship between insects and crops, the destructive outbreaks of insect pests, and various reasons for upsets in the balance. State and agricultural entomologists were called upon to prove or dispel information presented in the popular agriculture press at the time. The entomological reports usually included aspects of insect bionomics along with illustrations followed by suggestions for control measures. Through this work, entomologists determined which insect species was "friend" or "foe." Also, during this period was a great debate on the "bird question" or the relationship between insects, birds, and crops. Along with ornithologists, entomologists were called upon to determine precise feeding habits of various birds. Most farmers and agriculturists learned to rely on the work of entomologists to provide reliable information on various insect life cycles. Entomologists were then expected to suggest strategies to manipulate the balance of nature for the benefit of farmers.

Profile of the American Entomological Community About 1870 (Chapter 8) is an extremely detailed examination of the demographics of entomologists in the later 19th century. The chapter provides quantitative data on the education background, place of birth, attended institutions, etc. for entomologists at that time. Interesting is a section on the active role of several pioneering women in entomology (e.g., Sara McBride, Maria Mitchell, Mary Murtfelt, Emily Smith, Charlotte Taylor, and Mary Treat) during a time when the discipline was male dominated. The entomological community of the 1870's had grown to about 900 serious investigators of which approximately 100 functioned as a publishing elite.

Chapter 9 (*Acceptance and Implications of Evolution*) discusses the important role American entomologists played in the support of evolutionary theory. This chapter highlights the various debates and controversies within the entomological community then. Outspoken advocates such as Walsh and Riley helped promote evolutionary theory, but the fact that many American entomologists were field-oriented allowed them to observe the great geographic and climatic variety of the North American continent. This coupled with an emphasis of agricultural entomology that many American workers shared, reinforced their understanding of the biological and ecological aspects of insects. What is particularly noteworthy is how quickly and with near unanimity, American entomologists accepted evolutionary theory (Darwinian or "Neo-Lamarckians") and incorporated it in their work. The Darwinian revolution placed entomologists in the center of the new field of evolutionary biology.

Chapters 10 and 11 are examples of two prominent evolutionary biology studies by American entomologists in the 19th century. Chapter 10 concentrates on the search for evolutionary explanations of variation and polymorphism of Lepidoptera (*William Henry Bates and Polymorphism in Butterflies*) while chapter 11 (*The Yucca Moth*) focuses on the coevoution of plants and animals. Both chapters underscore the contributions of American entomologists toward acceptance of evolutionary theory in the scientific community.

The Debate over Entomological Nomenclature (Chapter 12) reflects the nomenclatural crisis that faced the entomological community in the 1870's. New Darwinian principles as applied to the definition of species and their systematic arrangement brought the issue to the foreground. The radical "splitting" of genera by some entomologists facilitated the debate. For entomology at the time, the inadequacy of nomenclatural rules presented a problem. It was argued by some that entomologists faced more pressing needs than other zoologists in the clarification of the rules of nomenclature. Debates such as these moved American entomologists to a prominence and special point of influence in internationally recognized rules of nomenclature.

The final chapter (*Conclusion*) summarizes the progress that American entomology made in such a short time during the 1800's. By 1880, entomologists were the largest single group of zoologists in North America. Along with the number of entomologists, knowledge of the North American insect fauna had also grown appreciably—not only in the total described species but also in the number of life history studies. The number of institutions teaching entomology or associated with the science too had grown. Entomological collections and outlets for publications had expanded substantially during the period. A discipline that began with a few amateur naturalists had developed into a fully professional group.

Brethren of the Net will have a special appeal for the student of history, science, or both and would make a wonderful companion to such books as Mallis' *American Entomologists* (Rutgers University Press, 1971) and Evan's *Pioneer Naturalists* (Henry Holt and Co., Inc., 1993). The work is well written, researched, amply footnoted, and I heartily recommend it. Sorensen has elaborated on events and individuals that have not only had an important influence on entomology but on science overall. Although some of these people or incidents are often forgotten, they should not be. Sorensen has gone a long way to remedy this. He has resurrected those people and events, and given the reader tremendous insight into the circumstances surrounding important episodes in science's past. As scientists we often forget that science too builds upon the work of others. Scientific knowledge does not spontaneously generate. *Brethren of the Net* goes a long way in proving this as it underscores the influence of previous events on our current work.

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OBITUARY

Jenaro Maldonado Capriles
1919–1995:
Biographical Sketch, Patronyms in His Honor, and List of Publications

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Jenaro Maldonado Capriles (Fig. 1), 76, died on 22 November 1995, in San Antonio, Texas. He is survived by his wife, Carmen; their children, Ricardo and María Teresa; a grandaughter, Jacqueline Marisa; and by many friends and colleagues.

Jenaro, as most of his colleagues called him, was born in Yauco, Puerto Rico, on 17 January 1919, where he attended primary and secondary school. In 1939, Maldonado finished his Bachelor's Degree in Agricultural Sciences at the "Colegio de Agricultura y Artes Mecánicas" (CAAM, now known as the Recinto Universitario de Mayagüez, RUM, of the University of Puerto Rico). He completed a Master's in Sanitary Sciences at the "Escuela de Medicina" (School of Tropical Medicine, now part of the Escuela de Medicina," UPR) in 1942. He related to one of us (JSB) that he became interested in medical entomology so he could work on something that would really make a difference in people's health. He served as an Entomologist for the Bureau of Malaria Control of the "Departamento Estatal de Salubridad" (State Health Department) from 1941 to 1948, as part of efforts to eradicate malaria in Puerto Rico. Those years yielded his first publication: "The fleas of Puerto Rico" (1945). In 1948, he joined the faculty of CAAM as an Assistant Professor. Maldonado received his doctorate from Ohio State University, Columbus, in 1956. His dissertation was entitled "A study of some Neotropical leafhoppers (Homoptera: Cicadellidae: Idiocerinae)"; Carl E. Vernard was his Major Professor. He viewed his years at OSU as interesting and enjoyable but all too short. Dr. Maldonado served as Chairperson of the Biology Department (CAAM) from 1960–1966 and as a faculty member of the Ponce School of Medicine from 1977–1982, where he was Chairman of the Department of Anatomy. He held numerous additional positions, including academic, administrative, community, and others, in Puerto Rico and worldwide.

Maldonado was also an avid field entomologist, frequently going on collecting expeditions to southeast Asia, the Caribbean, North Africa, and South Africa, among others. He was enthusiastic in initiating new and biologically interesting research, particularly in the Hemiptera. His taxonomic work mainly involved the hemipteran families Cicadellidae (Auchenorrhyncha), Miridae (Heteroptera), and Reduviidae (Heteroptera). Like most systematists, he had a few major projects and many side investigations going on simultaneously, always pursuing his science with excitement and enthusiasm, just as traditional country Puerto Rican children might open their presents on Three Kings Day. Even at an advanced age, he eagerly talked about learning and applying new technologies to his research, including scanning electron microscopy, which he incorporated into some of his later publications. His 704-page "Systematic Catalogue of the Reduviidae of the World" (1990), undoubtedly, is his major contribution to entomology. Another important work is his Miridae of Puerto Rico, published in 1969 (and supplemented by additions and corrections in 1991).

Maldonado's reputation as a concerned pedagogue and strict teacher always fol-

Fig. 1. Dr. Jenaro Maldonado Capriles at the Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C., 1981.

Fig. 2. Dr. Jenaro Maldonado Capriles (right) with Dr. José Ramos at a meeting of the Sociedad Entomológica de Puerto Rico, *circa* 1980.

lowed him. He rewarded students for hard and careful work and had a profound dislike for those who were disinterested. He held similar views about local politicians and physicians. Along with his wife Carmen, he was in charge of the Honor's Program at CAAM for several years. From the late 1950s, his efforts to further Puerto Rican education emphasized nursing, medical technology, numerous biology courses, and university libraries, mostly at CAAM.

Professor Maldonado was open and enthusiastic, and was still vigorously pursuing his entomological research until the time of his death. Along with recently deceased Professor José Ramos (Fig. 2), Maldonado's death constitutes a major loss to Entomology in Puerto Rico and the world.

Maldonado's private insect collection of approximately 300 Schmidt boxes, involving more than 18,000 specimens, and most of his primary types are now housed in the National Museum of Natural History Smithsonian Institution (Washington, D.C.).

For a limited time, reprints of Maldonado's more recent papers, except the Catalogue, can be obtained by writing to Dr. Carmen Acosta Maldonado (Calle 6-I-1, Urbanización Aponte, Cayey, PR 00736). His catalogue can be purchased from the Caribbean Journal of Science, Special Publications, Recinto Universitario de Mayagüez, Mayagüez, PR 00680, at a cost of $US15.00, plus shipping and handling.

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We thank Dr. Carmen Acosta Maldonado (San Juan Bautista School of Medicine, San Juan, Puerto Rico) for providing us with a copy of Jenaro's *Curriculum Vitae.* Luis Felipe Martorell, Silverio Medina-Gaud, and Mario Pérez-Escolar (Crop Protection Department, University of Puerto Rico, Mayagüez) provided some details of Professor Maldonado's early years. Dr. David L. Denlinger (Chairman, Department of Entomology, Ohio State University, Columbus) also provided data concerning Maldonado's years at OSU. Jo-Anne Hayes (Librarian, Agricultural Experiment Station, University of Puerto Rico), Andrew L. Hicks (Boulder, Colorado), and F. C. Thompson (Systematic Entomology Laboratory [SEL], ARS, USDA, c/o National Museum of Natural History, Washington, D.C.) kindly provided some of the literature to complete the list of patronyms. Drs. R. C. Froeschner (National Museum of Natural History [NMNH], Washington, D.C.), D. A. Polhemus (NMNH), D. R. Smith (SEL), and F. C. Thompson (SEL) read the manuscript and offered suggestions for its improvement.

PATRONYMS NAMED IN HONOR OF JENARO MALDONADO-CAPRILES

Alienates maldonadoi Wygodzinsky and Schmidt. 1991. Bull. Am. Mus. Nat. Hist. 200: 228. [Heteroptera: Enicocephalidae]. Distribution: Jamaica.

Ambrysus maldonadus [*sic*] La Rivers. 1954. Entomol. News 65: 197. [Heteroptera: Naucoridae]. Distribution: Venezuela.

Antias maldonadoi Carvalho. 1982. Rev. Brasil. Biol. 42(3): 331. [Heteroptera: Miridae]. Distribution: Dominican Republic.

Arenasella maldonadoi Caldwell. 1951. J. Agric. Univ. Puerto Rico 34: 224.

[Auchenorrhyncha: Flatidae]. Distribution: Puerto Rico. [The original spelling, *A. maldonadi,* is incorrect and is here **emended** (second "o" of patronym added).].

Balocha maldonadoi Kameswara Rao and Ramakrishnan. 1979. J. Bombay Nat. Hist. Soc. 76: [Auchenorrhyncha: Cicadellidae]. Distribution: India. [The original spelling *B. maldanadoi* is incorrect is here **emended** (second "a" of patronym changed to "o")].

Coronigoniella maldonadoi Young. 1977. Tech. Bull. 239, North Carolina Agric. Exp. Stn. (Raleigh). p. 1020. [Auchenorrhyncha: Cicadellidae]. Distribution: Venezuela.

Deltocoelidia maldonadoi Kramer. 1961. Proc. Biol. Soc. Wash. 74: 238. [Auchenorrhyncha: Cicadellidae]. Distribution: Venezuela.

Diphleps maldonadoi Henry. 1977. Florida Entomol. 60: 206. [Heteroptera: Miridae]. Distribution: Puerto Rico.

Ectomocoris maldonadoi Cai and Lu. 1991. Entomotaxonomia 13: 243. [Heteroptera: Reduviidae]. Distribution: China.

Guanabarea maldonadoi Carvalho. 1984. Rev. Brasil. Biol. 44(3): 320. [Heteroptera: Miridae]. Distribution: Puerto Rico.

Hadria maldonadoi Young. 1977. Tech. Bull. 239, North Carolina Agric. Exp. Stn. (Raleigh). p. 974. [Auchenorrhyncha: Cicadellidae]. Distribution: Dominican Republic.

Hermaeophaga maldonadoi Blake. 1965. Proc. Entomol. Soc. Wash. 67: 109. [Coleoptera: Chrysomelidae]. Distribution: St. Thomas.

Hexatoma maldonadoi Alexander. 1952. J. New York Entomol. Soc. 60: 245. [Diptera: Tipulidae]. Distribution: Venezuela.

Idioscopus capriliana Viraktamath and Murphy. 1980. [Auchenorrhyncha: Cicadellidae]. J. Entomol. Res. 4:85. Distribution: India.

Idioscopus caprilei Webb. 1976. J. Entomol. Soc. S. Afr. 39: 304. [Auchenorrhyncha: Cicadellidae]. Distribution: Nigeria. [This species is now in the genus *Pretioscopus*].

Lepidocyrtus maldonadoi Mari Mutt. 1986. Carib. J. Sci. 22 (1–2): 13. [Collembola: Entomobryidae]. Distribution: Puerto Rico.

Longurio maldonadoi Alexander. 1953. J. New York Entomol. Soc. 61: 147. [Diptera: Tipulidae]. Distribution: Venezuela.

Maldonadora Webb. 1983. Bull. Brit. Mus. Nat. Hist. 47: 228. [Auchenorryncha: Cicadellidae].

Minasmiris maldonadoi Carvalho. 1985. Rev. Brasil. Zool. 3(4): 163. [Heteroptera: Miridae]. Distribution: Colombia.

Monobelus maldonadoi Ramos. 1957. J. Agric. Univ. Puerto Rico 41: 104. [Auchenorrhyncha: Membracidae]. Distribution: Puerto Rico.

Prepops maldonadoi Carvalho and Fontes. 1973. Rev. Brasil. Biol. 33: 543. [Heteroptera: Miridae]. Distribution: Dominican Republic.

Sthenaridea maldonadoi Schuh and Schwartz. 1988. Bull. Am. Mus. Nat. Hist. 187: 189. [Heteroptera: Miridae]. Distribution: Mexico; widespread in Neotropics.

Wiloatma caprilesi Webb. 1983. Aust. J. Zool. Suppl. Series 92: 76. [Auchenorrhyncha: Cicadellidae]. Distribution: Australia.

PUBLICATION LIST

The following is a list of Maldonado's 157 scientific publications. Most of his papers deal with various groups of Heteroptera, particularly the Reduviidae and Miridae. He also conducted research in other arthropod groups, many of economic importance: Acari (Ixodida), Hemiptera: Auchenorrhyncha (Cicadellidae, Issidae, and Tropiduchidae), Anoplura, Mallophaga, Coleoptera (Scarabaeidae and Lymexylonidae), and Diptera (Culicidae, Syrphidae, and Tabanidae). In addition, Maldonado wrote about a dozen popular articles that are not listed. We also note that there are several other papers in preparation that will include Maldonado as an author, but these are not far enough along to be included here.

1. Maldonado Capriles, J. 1945. The fleas of Puerto Rico. Puerto Rico J. Public Health Trop. Med. 21:173–183 [also in Spanish 21: 184–192].
2. Maldonado Capriles, J. 1948. Three new neotropical species of the reduviid genus *Ploiaria* Scopoli (Hemiptera). Proc. Entomol. Soc. Wash. 50: 18–22.
3. Maldonado Capriles, J. 1948. A new *Enicocephalus* from Puerto Rico. Proc. Entomol. Soc. Wash. 50: 159–160.
4. Rehn, J. W. H., J. Maldonado Capriles, and J. M. Henderson. 1950. Field studies on the bionomics of *Anopheles albimanus.* Parts II and III: Diurnal resting places—Progress Report. J. Natl. Malaria Soc. 9: 268–279.
5. Drake, C. J. and J. Maldonado Capriles. 1952. Water striders from Territorio Amazonas, Venezuela. Great Basin Nat. 12: 47–54.
6. Fox, I. and J. Maldonado Capriles. 1953. Light trap studies on mosquitoes and *Culicoides* in western Puerto Rico. Mosquito News 13: 165–166.
7. Maldonado Capriles, J. 1953. Five new neotropical species of *Ghilianella* (Hemiptera, Reduviidae). Proc. Entomol. Soc. Wash. 55: 189–195.
8. Maldonado Capriles, J. 1953. Redescription of the genus *Burtinus* Stål and description of a new species from Puerto Rico (Hemiptera: Coreidae). Proc. Entomol. Soc. Wash. 55: 40–44.
9. Drake, C. J. and J. Maldonado Capriles. 1954. Puerto Rican water-striders (Hemiptera). Proc. Biol. Soc. Wash. 67: 219–221.
10. Maldonado Capriles, J. 1954. A note on the genus *Idiotettix* Osborn (Homoptera, Cicadellidae). Proc. Entomol. Soc. Wash. 56: 247–250.
11. Maldonado Capriles, J. 1955. *Cryptotylus stonei,* a new tabanid from Venezuela (Diptera, Tabanidae). Proc. Entomol. Soc. Wash. 57: 189–190.
12. Maldonado Capriles, J. 1955. Four new Venezuelan reduviid bugs. Proc. U.S. Natl. Mus. 104: 105–113.
13. Drake, C. J. and J. Maldonado Capriles. 1955. Some pleids and water-striders from the Dominican Republic (Hemiptera). Bull. Brooklyn Entomol. Soc. 51: 53–56.
14. Drake, C. J. and J. Maldonado Capriles. 1955. New apterous Aradidae from Puerto Rico (Hemiptera). J. Wash. Acad. Sci. 45:289–294.
15. Drake, C. J. and J. Maldonado Capriles. 1956. A remarkable new *Rhagovelia* from the Dominican Republic (Hemiptera: Veliidae). Bull. S. Cal. Acad. Sci. 55: 14–17.
16. Maldonado Capriles, J. W. F. Pippin, and M. L. Kuns. 1958. An annotated check list of the mosquitoes of Mona Island, Puerto Rico, and the larva and male of *Aedes obturbator* D. & K. (Diptera, Culicidae). Proc. Entomol. Soc. Wash. 60: 65–68.
17. Maldonado Capriles, J. and S. M. Rafi. 1958. Results of malariometric surveys performed between 1939 & 1957 in northern West Pakistan. Pakistan J. Health 8: 87–90.
18. Drake, C. J. and J. Maldonado Capriles. 1959. A new tingid from Pakistan (Hemiptera). Bull. Brooklyn Entomol. Soc. 54: 25–26.
19. Mariota Trias, F. and J. Maldonado Capriles. 1959. Insectos perjudiciales a la caña de azúcar y su combate. Rev. Agric. Puerto Rico 46: 67–74.
20. Maldonado Capriles, J. and A. S. Nasir. 1960. DDT-resistant adults of *Anopheles subpictus* in the Lahore District of West Pakistan. Mosquito News 20: 52–54.
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23. Maldonado Capriles, J. and C. A. Navarro. 1962. Number of insect species reported from Puerto Rico. Carib. J. Sci. 2: 22–26.
24. Gurney A. B. and J. Maldonado Capriles. 1962. On the cricket *Hygronemobius alleni* (Morse), with special reference to a first record of the genus in Puerto Rico (Orthoptera, Gryllidae). Carib. J. Sci. 2: 156–158.
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26. Rivero, J. A., J. Maldonado Capriles, and H. Mayorga. 1963. On the habits and food of *Eleutherodactylus karlschmidti* Grant. Carib. J. Sci. 3: 25–27.
27. Maldonado Capriles, J. 1963. A new species of *Ghilianella* from Haiti (Hemiptera Reduviidae). Proc. Entomol. Soc. Wash. 65: 64–66.
28. Maldonado Capriles, J. 1964. Studies on Idiocerinae leafhoppers: II. The Indian and Philippine species of *Idiocerus* and the genus *Idioscopus* (Homoptera: Cicadellidae). Proc. Entomol. Soc. Wash. 66: 89–100.
29. Maldonado Capriles, J. 1965. Studies on Idiocerinae leafhoppers: III. On Singh-Pruthi's Indian species of *Idiocerus* (Homoptera, Cicadellidae). Proc. Entomol. Soc. Wash. 67: 244–246.
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new lacebug from Haiti (Hemiptera: Tingidae). J. Kansas Entomol. Soc. 38: 317–319.

31. Maldonado Capriles, J. 1966. Sobre algunos emesinos (Reduviidae, Hemiptera) venezolanos y descripción de nuevas especies. Mem. Soc. Cienc. Natur. La Salle 26: 195–204.
32. Maldonado Capriles, J. 1966. A note on *Zanchisme* (Hemiptera: Miridae). Proc. Entomol. Soc. Wash. 68: 21–24.
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SOCIETY MEETINGS

1016th Regular Meeting—January 9, 1997

The 1016th Regular Meeting of the Entomological Society of Washington (ESW) was called to order at 8:02 pm by President M. Alma Solis on January 9, 1997, in the Waldo Schmitt Room of the National Museum of Natural History, Washington, DC. There were 9 members and 8 guests present. The minutes of the December 5, 1996, meeting were read by Acting Recording Secretary, Dawn Southard. This included a correction to a correction to the November 1996 minutes. It was stated that one of the visitors to the December '96 ESW meeting, Manual Balcazar, had already earned his Ph.D., and was at the Instituto de Biología, UNAM, Mexico; not still a student at the University of Florida. The minutes were then approved as corrected.

There were no officers' reports, no committee reports, and no old business. President Solis asked if anyone had notes or exhibits. Warren Steiner showed and passed around a new book from South Africa, which had been given to him by our evening's speaker, Dr. Bellamy, entitled: *Revision of the Tribe Caenocrypticini, Coleoptera: Tenebrionidae: Tentyriinae* by S. Endrody-Younga, Transvaal Museum Monograph No. 11. Oct. 1996, ISBN 0-907990-177. David Furth showed and passed around a new book, entitled: *An Inordinate Fondness for Beetles* by Arthur V. Evans and Charles L. Bellamy [our evening's speaker], 1996, published by Henry Holt & Co.; ISBN 0-8050-3751-9. David Furth also showed a new T-shirt covered with illustrations of insects (mainly beetles) of the world. M. Alma Solis described a children's book she had recently read called "Miss Spider's Tea Party."

David Furth, ESW Program Chair, introduced our speaker for the evening: Dr. Charles L. Bellamy, Coleoptera Department; Transvaal Museum; P.O. Box 413; Pretoria 0001, South Africa. Dr. Bellamy earned his B.S. and M.S. from California State University–Long Beach, under Dr. Sleeper; and his D.Sc. from the University of Pretoria, South Africa. His presentation, entitled "Beetle Collecting in Southern Africa," gave a brief overview of the habits, physiography, and peoples of southern Africa (especially Malawi, South Africa, and Zimbabwe), followed by a general discussion of beetle diversity. Many excellent slides were shown of the region's diverse habitats, geological features, vegetation, megafauna, and a number of more commonly encountered beetle species.

Five visitors were introduced: Dennis Hollier, manager of a Georgetown area hotel and husband of our acting recording secretary, Dawn Southard; Steve Lingafelter, a new staff member of the Systematic Entomology Laboratory; Dr. Alfonso Alonso, a former student of Dr. Brower at the University of Florida; Dr. Leeanne E. Alonso, who earned her Ph.D. from Harvard followed by a postdoctoral fellowship studying ant-plant interactions at the University of Oklahoma; and Dr. John W. Brown, who earned his Ph.D. from the University of California, Berkeley, and is a new Systematic Entomology Laboratory staff member.

President Solis adjourned the meeting at 9:10 pm. Refreshments were provided by Jil Swearingen and Warren Steiner.

Respectfully submitted,
Harold J. Harlan,
Recording Secretary

1017th Regular Meeting—February 6, 1997

The 1017th Regular Meeting of the Entomological Society of Washington (ESW) was called to order at 8:01 pm by President M. Alma Solis on February 6, 1997, in the Waldo Schmitt Room of the National Museum of Natural History, Washington, DC. There were 14 members and 4 guests present. The minutes of the January 9, 1997, meeting were read by Recording Secretary, Harold Harlan. David Furth pointed out that Dr. John W. Brown, a visitor at the January 9, 1997 meeting, was working at the USDA's Systematic Entomology Laboratory, not at the Smithsonian; and that he had earned his Ph.D. at U.C. Berkeley, not at San Diego. The spelling of one visitor's name was corrected to "Leeanne" Alonso. The minutes were approved after those corrections.

There were no officers' reports, no committee reports, and no old business. President Solis asked if there were any visitors or new members. Dr. John W. Brown became a new member since the January '97 meeting. President Solis asked if anyone had notes or exhibits. David Smith showed the new Memoir of the ESW (No. 18), *Contributions on Diptera, dedicated to Willis W. Wirth* and edited by Wayne Mathis and William L. Grogan, Jr. He also briefly discussed the confusion which might arise because the date inside was 1996, but the mailing date was January 1997. He next showed and passed around a nice picture of a large (25 mm), north temperate sawfly, *Cimbex americana* Leach, from Washington State. Anyone sighting such specimens around here please let him know. It is an elm sawfly, also found on willow and weeping willow. He further commented that we should be alert for sawfly activity soon. His earliest record of sawflies in this area has been February 17. President Solis referred us all to Georgia Brown's restaurant on 16th St. (just south of K St.) in NW DC, which has sawflies (about 3-in. long) painted in gold on its front doors and windows. David Furth showed and passed around three new books: *Spineless Wonders,* by Richard Coniff (our scheduled April 1997 speaker), 1996, published by Henry Holt & Co, NY, ISBN: 0-8050-4218-0; and two volumes by Gordon M. Nishida & Joann M. Tenorio—*What's Bugging Me?,* 1995, Univ. of HI Press, ISBN: 0-8248-1742-7; and *What Bit Me?,* 1993, Univ. of HI Press, ISBN: 0-8248-1492-4. Ed Saugstad showed and passed around a copy of a pamphlet from Japan entitled: "Techno Insect," [Vol. 26 (No. 6): 8–34, June 1993], which highlighted the known and potential value of insects from a technologic point of view.

David Furth announced that next month's speaker will be Eric Grissell, of SEL, USDA. He then introduced this evening's speaker, our Past President, Dr. Ralph Eckerlin: Northern Virginia Community College, Annandale, VA. Ralph earned his B.S. in Biology from Rutgers, and his M.S. in Zoology from the Univ. of Miami, FL, with research emphasis on flukes. He worked 7 years for American Cyanamid, then "wormed" his way back into pursuing a Ph.D., at the Univ. of CT with research on nematodes. He shared an office with Harry Painter for several years, and they collaborated on most of the research included in this evening's talk. His presentation, entitled: "Ectoparasite Potpourri," summarized several years of research on ectoparasites. Much of it related to fleas, their biology and zoogeography. Large changes in relative proportions of nest-inhabiting fleas of southern flying squirrels were discussed. These changes were associated with time of year, temperature, and elevation. *Orchopeas howardii* (Baker) was dominant at lower elevations and summer; but was replaced by *Opisodasys pseudarctomys* (Baker) at higher elevations (≥2000 ft.) in winter. Observed distributions of some of these flea species suggest "mountaintop speciation" along the Appalachians. Later studies on ticks and on leptinid beetles (Coleoptera: Leptinidae) were also discussed. Some very good slides were included of recent ectoparasite studies Dr. Eckerlin had done in Central America with local national and U.S. collaborators.

The meeting was adjourned at 9:07 pm. Refreshments were provided by M. Alma Solis.

Respectfully submitted,
Harold J. Harlan,
Recording Secretary

1018th Regular Meeting—March 6, 1997

The 1018th Regular Meeting of the Entomological Society of Washington (ESW) was called to order at 8:04 pm by President M. Alma Solis on March 6, 1997, in the Waldo Schmitt Room of the National Museum of Natural History, Washington, DC. There were 18 members and 9 guests present. The minutes of the February 6, 1997, meeting were read by Recording Secretary, Harold Harlan.

There were no officers' reports and no old business. Holly Williams reported, on behalf of the Membership Chair, there are seven prospective new members this month (March 1997). They are: Carol DiSalvo; Warren G. Abrahamson; Marion Kotrba; Alexander S. Konstantinov; Steve Lingafelter; Steve W. Chordas, III; and Diane M. Calabrese. David Furth reported, on behalf of the Executive Committee, that regular ESW meetings will begin earlier: April's meeting will begin at 7:30 pm, and subsequent meetings may be moved up to start at 7:00 pm. No new members were present. David Furth introduced a visitor, Andy Brower, a Post-doctoral Fellow studying Lepidoptera at the USNM. President Solis then asked for presentation of any notes or exhibits. Dr. Louis J. Pribyl, a research collaborator in the Department of Paleobiology, Smithsonian, showed and briefly discussed fossil insects he had displayed at the back of the room. These were Eocene (Green River) fossil insects from Piceance Creek Basin, CO. He invited any experts to assist in identifying these specimens and provided an information sheet and invitation to interested parties (copies are on a rear table). Please review one of these and take a copy with you for further review or follow-up. David Furth showed and placed on display three new publications of possible interest to members: *Insects of the Great Lakes Region,* by Gary Dunn, 1996; published by the Univ. of Michigan Press, Ann Arbor; ISBN (hard cover): 0-472-09515-3; ISBN (paperback): 0-472-06515-7. *Nomina Insecta Nearctica: A Checklist of the Insects of North America; Diptera, Lepidoptera, and Siphonaptera.* Vol. 3, 1996; compiled by R. W. Poole & R. E. Lewis; by Entomological Information Services, Rockville, MD; ISBN (series): 1-889002-00-3; ISBN [Vol. 3]: 1-889002-03-8; and a pamphlet-style report on the Permits Workshop, San Diego, CA, 29–31 January 1997. Gabriela Chavarria showed and passed around a book entitled: *The Conservation of Bees,* by A. Matheson, S. L. Bachmann, C. O'Toole, P. Westrich, & I. H. Williams, 1996; by Academic Press, San Diego, CA; ISBN: 0-12-479740-7. Ralph Eckerlin showed and placed on display a small metal can of DDT powder, which he had found among the possessions of the late Dr. Robert Traub, a long-time ESW member and a well-known flea specialist. David Furth next read a limerick related to the speaker's subject matter; and then introduced the evening's speaker, Dr. Eric Grissell, SEL, USDA. Dr. Grissell earned his B.S., M.S., and his Ph.D. from U.C. Davis. He received his Ph.D. in 1972, studying the origins of western species of *Torymus* in the U.S.

Biological diversity is very topical, and within the biological community it is greatly pondered, debated, and written about. Biologists generally agree that a biodiversity "crisis" exists. Each biologist's reaction to the dilemma may be focused on the perspective from his or her own specialized point of view. Biologists are not the only students of biodiversity, and we may fail to heed the notion that dissidents to the concept of biodiversity exist and that they voice opinions which most mainstream biologists find appalling. To the overwhelming majority of "the public," the concept of biodiversity is at best an acknowledgment that life exists and at worst a violent aversion to any lifeform that enters their personal space.

Dr. Grissell illustrated some notions about biodiversity that might seem alien to most of us, and briefly explored the notion that biodiversity is not a universally accepted paradigm within the scientific community (or in some cases what passes as the scientific community). He presented a minimum number of factoids concerning Hymenoptera and discussed aspects of their biodiversity that may be foreign to most of us. And he presented some notions of public perception concerning Hymenoptera and insects and suggested that it is up to biologists to help make biodiversity a household word of some importance to the majority of the public. This is still quite a challenge.

The speaker's approach reflected his perspective as a systematist with a lifelong interest in the environment and its biodiversity. Because he is a specialist in the Hymenoptera, he used examples from that group to illustrate his points. Although that may have appeared to be an insular choice, he was not entirely convinced that other groups of organisms, for example the beetles, could provide more suitable examples or make more sense.

The meeting was adjourned at 9:09 pm. Refreshments were provided by Harold Harlan.

Respectfully submitted,
Harold J. Harlan,
Recording Secretary

1019th Regular Meeting—April 3, 1997

The 1019th Regular Meeting of the Entomological Society of Washington (ESW) was called to order at 7:30 pm by President M. Alma Solis on April 3, 1997, in the Waldo Schmitt Room of the National Museum of Natural History, Washington, DC. There were 13 members and 15 guests present. The minutes of the March 6, 1997, meeting were read by Recording Secretary, Harold Harlan.

There were no officers' reports and no old business. Holly Williams reported, on behalf of the Membership Chair, that three new members are Kipling Will, Marty Condon, and Lynn E. Carroll.

Under new business, President Solis announced that the Executive Committee had met and decided how to handle the excess archived publications of the ESW. David Furth has volunteered to contact some book dealers as a possible partial solution to this problem. President Solis asked for presentation of any notes or exhibits. David Furth showed and placed on display two publications of possible interest to members: *Thermal Warriors; Strategies of Insect Survival* by Bernd Heinrich, 1996; published by Harvard Univ. Press, Cambridge, MA.; ISBN (hard cover): 0-674-88340-3; and *The Hot-Blooded Insects: Strategies and Mechanisms of Thermoregulation*; by Bernd Heinrich, 1993; published by Harvard Univ. Press, Cambridge, MA; ISBN (hard over): 0-674-40838-1.

David Furth announced that the Entomology Dept., Smithsonian Institution, has a lot of excess sheets of old-fashioned (= "real") papered cork, each about 10″ × 20.″ He showed one such sheet. Interested persons should contact him. He also described a computer mouse pad which is designed to look like a ladybird beetle. Warren Steiner announced that the annual ESW Banquet will be held Tuesday evening, June 3rd, 1997, at the Uniformed Services Univ. dining room. The speaker will be Mark Moffet, a well known photo-journalist, from the Museum of Comparative Zoology, Harvard University. David Furth next introduced our speaker for the evening, Richard Conniff, a widely known nature journalist.

Richard Conniff is from Deep River, CT. He is a prolific and accomplished writer and producer of nature (especially invertebrate animals) topics. He became interested in nature relatively late in life. He earned a B.S. in English from Yale (Class of 1973) and worked as a journalist for a daily newspaper until he found "leeches were more interesting than politicians." His subsequent works usually detail natural subjects and often compare them to our frequently "unnatural" everyday human lives. He has written for *Time, Smithsonian, Atlantic Monthly, The New York Times,* and *Nation-*

al Geographic, among others. He has narrated and written and produced television shows for the "National Geographic Explorer," the Discovery Channel, and other network nature specials. His script for one National Geographic show, "Ocean Drifters" was nominated for an Emmy Award in 1993. He has recently written a book, *Spineless Wonders,* published by Henry Holt & Co. (ISBN: 0-8050-4218-0), from which he drew much of his talk. He showed some excellent slides of various aspects of four main invertebrate groups: fire ants, tarantulas, fleas, and moths. Both his verbal and pictoral illustrations were often striking. For example, he compared the reproductive function of a fire ant queen to be roughly equivalent to "a 120-lb. woman giving birth to 500,000 eight-pound babies a year"; he described tarantulas as "spiders in a mink coats" and stated that they are the "dominant predators of the rain forest"; he noted that men once wooed women with "poetry about their fleas"; and he described and showed examples of how moths' eggs mimic bird droppings and their larvae mimic twigs and lichens on trees. The talk was fascinating and concurrently very entertaining. A few copies of his book were available for purchase and he signed those purchased after the meeting.

The meeting was adjourned at 8:49 pm. Refreshments afterward were provided by John Brown.

Respectfully submitted,
Harold Harlan,
Recording Secretary

1020th Regular Meeting—May 1, 1997

The 1020th Regular Meeting of the Entomological Society of Washington (ESW) was called to order at 7:53 pm by President M. Alma Solis on May 1, 1997, in the Waldo Schmitt Room of the National Museum of Natural History, Washington, DC. There were 16 members and 10 guests present. The minutes of the April 3, 1997, meeting were read by Recording Secretary, Harold Harlan.

Under Officers' reports, President Solis announced that the former Membership Chair, David Adamski, resigned that position and John Brown has been appointed as the new Membership Chair. Warren Steiner announced that Mark Moffett, our planned banquet speaker, has been given, with very little notice, an important assignment in Vietnam and will not be available on June 3. However, Bernd Heinrich, Zoology Department, University of Connecticut, has agreed to speak at our banquet. His tentative title will be something like "Adventures with Hot and Cold Dung-Rolling Beetles."

There were no other officers' reports or committee reports. John Brown, Membership Chair, read names of two new members: Patricia Jimenez Guarda and Imelda Martinez Morales. Two visitors were introduced. David Furth introduced Dr. Lee, a visiting scientist from Andong University, Republic of Korea, working on chrysomelids. Harry Painter introduced his wife, Audrey.

David Furth announced that Lee Goff, a well-known Forensic Entomologist and Acarologist from the University of Hawaii, will be visiting this area and will present a talk on Forensic Entomology, here in the Waldo Schmitt Room, at 1:00 pm Tuesday, May 20, 1997. Everyone is invited.

President Solis asked for presentation of any notes or exhibits. Paul Spangler showed and passed around a colored picture of two lucanid beetles with mites on them (one was almost completely covered). He also showed and passed around two fossil beetles: one was a scarab from Ecuador; the other was probably a dyticid from Washington. David Furth showed and placed on display four publications of possible interest to members: 1. *Ecology of Coccinellidae* by I. Hodek and A. Honek, 1996; published by Kluwer Academic Publishers, Dordrecht, ISBN (hard cover): 0-7923-4177-5; 2. *Canopy Arthropods,* ed. N. E. Stork, J. Adis, and R. K. Didham, 1997; published by Chapman and Hall, London, ISBN (hard cover): 0-412-74900-9; 3. *Keys to the Insects of the European Part of the USSR.* (Translation), Vol. III, Hymenoptera, Part 5. ed., G. S. Medvedev, 1995; Science Publishers, Inc. Published by the Institute of Zoology, Academy of Sciences of the USSR. No. 147, ISBN: 1-886106-24-X, printed at Baba Barkha Nath Press, New Delhi: and 4. *The Carrion Beetles (Coleoptera: Silphidae) of Nebraska* by Brett C. Rattcliffe, Bull. of the University of Nebraska State Museum, Vol. 13, 1996; published by the University of Nebraska State Museum, ISBN: 0093-6812.

David Furth next introduced our speaker for the evening, Mila Coca, who is nearing the end of a two-year post-doctoral fellowship provided by her own Spanish government. Mila had earned her Ph.D. in Madrid, Spain, studying the phylogeny of scarabaeid beetles. She will soon return to a position in the National Museum of Spain. She has been studying *Phyllophaga* spp. of the U.S. under Terry Erwin at the Smithsonian Institution.

Her talk addressed relationships of taxa within the Melolanthini ("May" or "June" beetles) of Europe and the U.S. She compared and contrasted their morphologies and, to some extent, their behavior. Larvae (subterranean forms) of certain groups are very territorial, and often kill congeneric or conspecific intruders. Mila discovered and used many new morphological characters of adult beetles' genitalia, sterna, and even internal structures in her studies. She noted that scanning electron micrographs can be very helpful. Her results may help more accurately identify serious agricultural pests in Spain.

The meeting was adjourned at 8:28 pm. Refreshments afterward were kindly provided by Paul and Phyllis Spangler.

Respectfully submitted,
Harold Harlan,
Recording Secretary

1021st Regular Meeting—June 3, 1997

The Annual Banquet of the Entomological Society of Washington (ESW) was held Tuesday, June 3, 1997, in the dining room of the Uniformed Services University of the Health Sciences (USUHS), Bethesda, MD, at 7:00 pm. The Maryland Entomological Society (MES) shared in sponsoring this event.

The evening began with a cash bar at 6:00 pm, accompanied by a lot of good conversation and fellowship. The meal was served at 7:00 pm followed by a brief program and the presentation by our invited speaker. President M. Alma Solis introduced David Furth, Master of Ceremonies for the evening. Very brief remarks were given by: Bob Platt, representing MES; Harold Harlan, representing USUHS; and Warren Steiner, ESW President-Elect. David Furth introduced our speaker, Dr. Bernd Heinrich, Department of Zoology, University of Vermont.

Dr. Heinrich's talk, on "Adventures with Hot and Cold Dung-ball Rolling Beetles," included comparisons of different strategies by dung-ball rolling beetles for finding and exploiting various kinds and sizes of dung. Those species with higher body temperatures seemed to have an edge in finding and beginning to process dung quickly. This could be very critical where dung is scarce or where it may dry out very quickly, thus becoming unusable. His talk also addressed different burying techniques and mating habits. He showed many fine slides of the beetles in action.

David Furth thanked our speaker for his excellent presentation, thanked everyone for attending (more than 70 people were present) and wished all a safe trip home. Alma Solis echoed those wishes, then closed the banquet at about 9:45 pm.

Respectfully submitted,
Harold Harlan,
Recording Secretary

RECENT PUBLICATIONS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Memoir No. 17

Contributions on Hymenoptera and Associated Insects,
Dedicated to Karl V. Krombein. Edited by B. B. Norden and A. S. Menke.
216 pp. 1996 (cost: $25.00)

A Festschrift in recognition of Dr. Karl V. Krombein, Smithsonian Institution, Washington, D.C. A collection of 22 invited papers, mostly on Hymenoptera, from Dr. Krombein's colleagues around the world. Biographic highlights and a bibliography of Dr. Krombein's publications by Beth B. Norden are presented.

Memoir No. 18

Contributions on Diptera, Dedicated to Willis W. Wirth.
Edited by Wayne N. Mathis and William L. Grogan, Jr.
297 pp. 1997 (cost: $25.00)

A memorial volume dedicated to D. Willis W. Wirth, eminent Dipterist and long-time employee of the Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington, D.C. A collection of invited papers, mostly on Diptera, prepared by Dr. Wirth's colleagues around the world.

Memoir No. 19

Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the
Western Hemisphere. By Thomas J. Henry.
149 pp. 1997 (cost: $18.00)

Western Hemisphere Berytidae include 3 subfamilies, 13 genera, and 53 species. Keys and numerous illustrations are provided for identification, and information on host plants, feeding habits, and economic importance are provided. An important, comprehensive work on this family.

Miscellaneous Publication

A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera)
Second Edition, Revised.
By E. Eric Grissell and Michael E. Schauff.
87 pp. 1997 (cost: $15.00)

This is a revised edition of the 1990 handbook on chalcids by the same authors. The content is updated with the numerous advances that have appeared since 1990. Pictorial keys and discussions of the characteristics, biology, distribution, and literature of each family as well as collecting and mounting techniques and morphology make this a most useful introduction and overview of the superfamily.

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PROCEEDINGS
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WASHINGTON

Volume 99

OFFICERS FOR THE YEAR 1997

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PUBLICATIONS FOR SALE BY THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

Miscellaneous Publications

Cynipid Galls of the Eastern United States, by Lewis H. Weld. 124 pp. 1959	$ 5.00
Cynipid Galls of the Southwest, by Lewis H. Weld. 35 pp. 1960	3.00
Pictorial Key to Species of the Genus *Anastrepha* (Diptera: Tephritidae), by George C. Steyskal. 35 pp. 1977	1.50
Taxonomic Studies on Fruit Flies of the Genus *Urophora* (Diptera: Tephritidae), by George C. Steyskal. 61 pp. 1979	2.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera), by E. Eric Grissell and Michael E. Schauff. 85 pp. 1990	10.00
A Handbook of the Families of Nearctic Chalcidoidea (Hymenoptera): Second Edition, Revised, by E. Eric Grissell and Michael E. Schauff. 87 pp. 1997	15.00

Memoirs of the Entomological Society of Washington

No. 1.	The North American Bees of the Genus *Osmia*, by Grace Sandhouse. 167 pp. 1939	$15.00
No. 2.	A Classification of Larvae and Adults of the Genus *Phyllophaga*, by Adam G. Boving. 95 pp. 1942	(out of print)
No. 3.	The Nearctic Leafhoppers, a Generic Classification and Check List, by Paul Wilson Oman. 253 pp. 1949	15.00
No. 4.	A Manual of the Chiggers, by G. W. Wharton and H. S. Fuller. 185 pp. 1952	15.00
No. 5.	A Classification of the Siphonaptera of South America, by Phyllis T. Johnson. 298 pp. 1957	15.00
No. 6.	The Female Tabanidae of Japan, Korea and Manchuria, by Wallace P. Murdoch and Hirosi Takahasi. 230 pp. 1969	15.00
No. 7.	Ant Larvae: Review and Synthesis, by George C. Wheeler and Jeanette Wheeler. 108 pp. 1976	11.00
No. 8.	The North American Predaceous Midges of the Genus *Palpomyia* Meigen (Diptera: Ceratopogonidae), by W. L. Grogan, Jr. and W. W. Wirth. 125 pp. 1979	12.00
No. 9.	The Flower Flies of the West Indies (Diptera: Syrphidae), by F. Christian Thompson. 200 pp. 1981	10.00
No. 10.	Recent Advances in Dipteran Systematics: Commemorative Volume in Honor of Curtis W. Sabrosky. Edited by Wayne N. Mathis and F. Christian Thompson. 227 pp. 1982	11.00
No. 11.	A Systematic Study of the Japanese Chloropidae (Diptera), by Kenkichi Kanmiya. 370 pp. 1983	18.00
No. 12.	The Holarctic Genera of Mymaridae (Hymenoptera: Chalcidoidae), by Michael E. Schauff. 67 pp. 1984	5.00
No. 13.	An Identification Manual for the North American Genera of the Family Braconidae (Hymenoptera), by Paul M. Marsh, Scott R. Shaw, and Robert A. Wharton. 98 pp. 1987	18.00
No. 14.	Biology and Phylogeny of Curculionoidea, edited by R. S. Anderson and C. H. C. Lyal. 174 pp. 1995	25.00
No. 15.	A Revision of the Genus *Ceratopogon* Meigen (Diptera: Ceratopogonidae), by A. Borkent and W. L. Grogan, Jr. 198 pp. 1995	25.00
No. 16.	The Genera of Beridinae (Diptera: Stratiomyidae), by Norman E. Woodley. 231 pp. 1995	25.00
No. 17.	Contributions on Hymenoptera and Associated Insects, Dedicated to Karl V. Krombein, edited by B. B. Norden and A. S. Menke. 216 pp. 1996	25.00
No. 18.	Contributions on Diptera, Dedicated to Willis W. Wirth, edited by Wayne N. Mathis and William L. Grogan, Jr. 297 pp. 1997	25.00
No. 19.	Monograph of the Stilt Bugs, or Berytidae (Heteroptera), of the Western Hemisphere, by Thomas J. Henry. 149 pp. 1997	18.00

Back issues of the Proceedings of the Entomological Society of Washington are available at $60.00 per volume to non-members and $25.00 per volume to members of the Society.

Prices quoted are U.S. currency. Postage extra except on prepaid orders. Dealers are allowed a discount of 10 per cent on all items, including annual subscriptions, that are paid in advance. All orders should be placed with the Custodian, Entomological Society of Washington, ℅ Department of Entomology, MRC 168, Smithsonian Institution, Washington, D.C. 20560.

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